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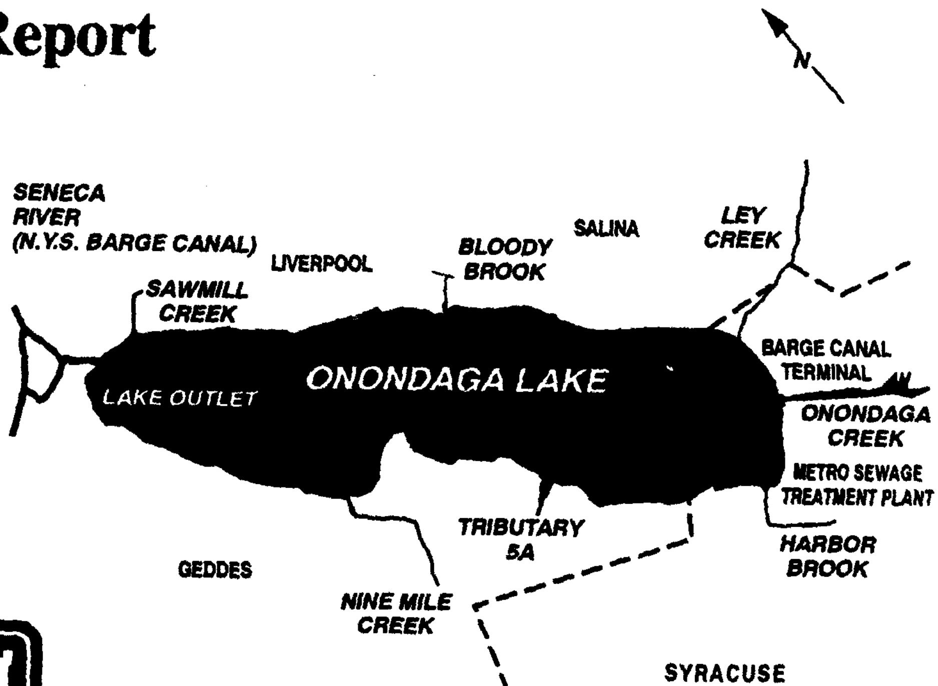
# TECHNICAL REPORT

## Onondaga Lake
## New York

## Main Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This technical report on Onondaga Lake, New York has compiled existing data to determine which water quality and environmental enhancements are advisable. The report identifies sediment and water quality problems and needs, potential clean-up methodologies, fisheries and fish habitat improvements, and water quality improvements.

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# EXECUTIVE SUMMARY

This study of Onondaga Lake was initiated based on a Senate Resolution by the Environment & Public Works Committee in June 1989. The Committee directed that the Corps review the Oswego River Basin report, and any other reports pertinent to determining what water quality or environmental enhancements are advisable to Onondaga Lake. Funding for this study was provided by Congress as an addition to the FY 90 & FY 91 appropriation acts.

The scope of the study includes (1) compilation of the existing data, (2) identification of sediment and water quality problems and needs, (3) identification and assessment of technologies to manage and treat contaminated sediments, (4) identification of potential methodologies, (5) investigation of fisheries and fish habitat improvements, (6) investigation of improvements to water quality for swimming and, (7) investigate water quality improvements to maintain a drinking water source needing minimal treatment.

Onondaga Lake has a surface area of 4.5 square miles and is located in the center of the urban Syracuse-Onondaga County metropolitan area. The development around the lake over the past 200 years has contributed to its current problems. The high chloride concentrations in the water contravene the State standards for fishing and drinking. The primary causes for the elevated chloride levels are former industrial discharges and leaching from the waste beds located adjacent to the lake. High sediment discharges from Onondaga Creek and other sources have created a problem with the transparency in the lake. Also the high sediment load has damaged the fish spawning areas. The major source of the sediment has been identified as Onondaga Creek in Tully Valley in an area known as the mud boil field. High fecal coliform bacteria is a problem during storm events causing contravention of the State swimming standards. The source of the problem has been identified as the combined sewer overflows (CSO's). High mercury levels in the sediments have contributed to high concentrations in the aquatic life. The former industrial discharges are primary sources of the mercury. Oxygen depletion is a problem in the hypolimnion. As a result, a cold water fishery cannot be maintained, metals leach out of and nutrients recycle from the bottom sediments, hydrogen sulfide and methane gases are produced, and high concentrations of ammonia accumulate in the hypolimnion. The dissolved oxygen depletion is a result of high nutrient loads and levels. The high phosphorus problem, produced mostly by the Metropolitan Sewage Treatment Plant (METRO) and internal releases from the sediments has several consequences. They include high algae productivity, dissolved oxygen depletion from algae decay, high sediment oxygen demand and decrease in transparency. High nitrogen loads produced by METRO discharge have resulted in high algae productivity, ammonia toxicity, nitrate toxicity, decreases in transparency and depletion of dissolved oxygen from algae decay.

The water quality of Onondaga Lake was evaluated in terms of attaining three goals.

- Produce a lake acceptable for contact recreation (swimming);
- Produce a lake acceptable for a cold water fishery (fishing); and
- Produce an acceptable drinking water supply with minimal treatment (drinking).

The primary problems with the water quality which restrict the achievement of the three goals are:

- Swimming - Lake is too turbid, has unacceptable high coliform counts because of CSO's, and has large algae blooms because of the high phosphorus loads from the METRO sewage treatment plant;
- Fishing - Lake has industrial pollutants such as mercury which accumulate in the fish, has insufficient oxygen because of the heavy amount of nutrients in the lake, and has too much turbidity.
- Drinking - Lake has industrial pollutants (mercury, chloride, etc.), is too turbid, and has too high a level of nutrients.

As part of the formulation process, various measures were developed and combined to address the three goals. They include: dredging of the lake; confined disposal facilities; solidification of the contaminated sediments; capping of the contaminated sediments; in-lake treatment which includes oxygenation and chemical treatment; and a settling basin near Onondaga Creek for a major non-point source. Measures were also developed for improvements to the METRO sewage treatment plant. These include additional removal of phosphorus, nitrogen and ammonia with continued effluent discharge to the lake or future discharge to the Seneca River. In addition to the METRO improvements, CSO treatment and/or diversion has been evaluated. These measures include separation of combined sewer systems, storage options, regional CSO collection and treatment, best management practices, high rate treatment facilities, in-water containment structures (flow balance methods and in-line tunnel storage). A measure has been developed for natural development to provide environmental enhancement features to Onondaga Lake.

Cost estimates were calculated or obtained for each of the measures. The CSO control and METRO upgrade costs have not been made available for public release by Onondaga County. The costs for the other measures are summarized in Table I.

The measures have been combined into alternatives to achieve a restoration goal or multiple of goals (reference - Table II). For the swimming goal, the following measures are required: regional combined sewer overflow collection and treatment is necessary to remove the coliform bacteria; the additional removal of phosphorus by METRO is necessary to reduce the algae productivity; improve dissolved oxygen; reduce the sediment oxygen demand; increase the transparency; and the mud boils must be controlled to improve lake and stream transparency.

## Cost Estimate Summary of Measures

| Measure Definition | Total First Cost $ |
|---|---|
| 1. Dredging of Onondaga Lake | |
| a. 6,500,000 Cubic Yards | 61,700,000 |
| b. 3,000,000 Cubic Yards | 28,500,000 |
| c. 2,000,000 Cubic Yards | 19,100,000 |
| 1.1 Confined Disposal Facilities (Integral with dredging) | |
| a. Design 1 (Confine 6.5 million CY in 22' of water) | 63,500,000 |
| b. Design 2 (Confine 6.5 million CY in 6' of water) | 50,700,000 |
| c. Design 3 (Confine 3 million CY) | 20,700,000 |
| d. Design 4 (Confine 2 million CY) | 17,500,000 |
| 1.2 Solidification of Contaminated Sediments ($80/CY) (Integral with dredging) | |
| a. 6,500,000 Cubic Yards | 520,000,000 |
| b. 3,000,000 Cubic Yards | 240,000,000 |
| c. 2,000,000 Cubic Yards | 160,000,000 |
| 2. Capping of Contaminated Sediments (0.5 feet sand) | |
| a. < 1 ppm mercury | 198,000,000 |
| b. < 5 ppm mercury | 162,000,000 |
| c. < 10 ppm mercury | 143,000,000 |
| 3. In-lake Treatment | |
| a. Aeration of the Hypolimnion | 1,378,000 |
| b. Chemical Treatment | 12,000,000 |
| 4. Non-point Sources | |
| a. Mud Boils on Onondaga Creek | 348,000 |
| b. Waste Beds | 400,000 to 95,300,000 |
| 5. Natural Development | 10,000 to 400,000 |
| 6. Metro Sewage Treatment Plant | |
| a. Phosphorus, Ammonia, & Nitrogen Removal | N/A |
| b. Effluent Discharge Alternative | N/A |
| 7. CSO Treatment or Diversion | |
| a. Regional CSO Treatment Facilities | |
| o Separation of Combined Sewer Systems | N/A |
| o Storage options | N/A |
| b. Centralized Treatment & Storage | |
| o High Rate Treatment Facilities | N/A |
| o In-water Containment Structures | N/A |
| o In-line Tunnel Storage | N/A |

Note: Onondaga County has not released the costs for the CSO control and METRO upgrade measures.

**Grouping of Measures into Alternatives - Onondaga Lake**

| Alternatives | Measures |
|---|---|
| **Alternative 1** - Swimming | Measure 3a - In-lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 6a - Removal of Phosphorus at METRO<br>Measure 7 - Control of CSO discharges |
| **Alternative 2** - Fishing | Measure 3a - In-lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 4b - Control Leaching from Waste Beds<br>Measure 6a - Removal of Phosphorus & Nitrogen at METRO |
| **Alternative 3** - Drinking | Measure 3 - In-lake Oxygenation<br>Measure 4b - Removal of Chlorides<br>Measure 6a - Removal of Phosphorus, Nitrogen, & Ammonia at METRO |
| **Alternative 4** - Multi-goal (Swimming, Fishing, Drinking) | Measure 3 - In-Lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 4b - Control Leaching from Waste Beds<br>Measure 6a - Removal of Phosphorus, Nitrogen, & Ammonia at METRO<br>Measure 7 - Control of CSO's |
| **Alternative 5** - Natural Development | Measure 5 - Environmental Enhancement for Wetlands and Wildlife |

The in-lake oxygenation measure will reduce the phosphorus loading by approximately 10 percent.

The improvements required to develop a cold water fishery will be achieved by combining the following measures: additional phosphorus and nitrogen removal at METRO is necessary to reduce the algae productivity. As a result, the transparency will improve, dissolved oxygen will improve, ammonia toxicity and nitrate toxicity will be eliminated and the sediment oxygen demand will be reduced. The in-lake oxygenation measure will prevent the excessive nutrients and metals from leaching out of the sediments. Methane and hydrogen sulfide production will be eliminated and hypolimnetic ammonia concentrations will be reduced. The control of mud boils will improve the transparency. Measures that control chlorides from the waste beds are required to meet the State standard for cold water fisheries.

To achieve the drinking water goal, the following combined measures are required: ammonia nitrification at METRO; chloride control from the waste beds; additional phosphorus removal at METRO; and in-lake oxygenation to prevent the metals from leaching out of the sediments. The impacts of these measures on the water supply goal have been discussed in the preceding section on cold water fisheries.

The conclusions that have been developed for this technical report are listed as follows:

1. The most effective measure to reduce pollutant loads to Onondaga Lake is re-routing of METRO discharge. Additional pollution abatement measures would be neccessary to avoid detrimental effects on the Seneca River. Current modeling efforts are addressing this issue.

2. The METRO total phosphorus discharge is the major source of nutrients to the lake. Reduction/elimination of this loading is a necessary element, if the lake's condition is to be shifted out of the eutrophic state. Although this action alone may not be sufficient to do so, improvements would be noticeable.

3. Ammonia controls including nitrification and a reduction in ammonia due to oxygenation will benefit the fish habitat as well as the drinking water goal.

4. CSO's must be controlled to achieve the swimming goal due to their discharge of coliform bacteria.

5. The least cost bacteria reduction measure is regional collection and treatment.

6. CSO's are a small source of phosphorus loads to the lake (compared to METRO phosphorus loads) but their control may be needed as a complement to actions at METRO. The selected CSO pollution reduction measures reviewed in this report have minor effects on phosphorus loads to the lake.

7. Dredging and capping measures which address mercury in the sediment, are likely to be very costly. The potential improvement and associated benefits are uncertain at the present time. Studies to more thoroughly evaluate measures to control mercury will begin in 1992 through a consent decree between the State of New York and Allied-Signal.

8. Remedial control of Allied-Signal waste beds is necessary, if in-lake chloride concentrations are to be brought within state water quality goals.

9. Mud boil sediment load must be reduced significantly to enable fish spawning in Onondaga Creek and increase transparency in the lake.

10. In-lake oxygenation is a measure that may contribute to noticeable improvements to the lake if carried out in concert with other, more basic, pollution controls. These potential improvements may include reduced nutrient and metal leaching from the sediments, a reduction of methane gases, a reduction in ammonia from the hypolimnion, and enough dissolved oxygen to maintain a cold water fish population in the lake. Whether these benefits would actually occur in the specific chemical environment of Onondaga Lake needs further evaluation.

11. In-lake chemical treatment for phosphorus removal is very costly and its benefits are temporary unless the external sources are removed.

12. There is not enough information on the mercury to determine the sources or the mechanism that causes it to cycle out of the sediments.

13. There is little information on organic compounds in the lake regarding how they interact between the sediments, water and aquatic life. More studies are needed in this area to better define the organic relations with this environment.

14. If actions are taken to improve water quality and develop a cold water fishery without additional actions to deal with in-place contaminants, fish could still be inedible.

15. The current modeling efforts by the Upstate Freshwater Institute need to be completed before an efficient solution can be formulated. These efforts are needed to predict how the lake will respond to changes in nutrient and pollutant loadings. There is a need to quantify the load reductions that each measure will have on a specific pollutant or nutrient. The lake models use this input to determine how the lake will respond to proposed loading changes.

16. A traditional plan formulation process based on the single objective of NED will not identify the best plan of improvement that meets the multiple objectives of swimming, fishing and drinking for the waters of Onondaga Lake. What is needed is a multi-objective plan formulation process with an adequate decision matrix to allow for the comparison of plans based on criteria such as: cost, acceptability, effectiveness, completeness, economic efficiency, and environmental desirability. Integral with this process is the necessary public involvement to address the issues of public necessity and acceptability.

**It should be noted that the material presented herein is a summary of material existing during its writing. Some of the material has not been peer reviewed or reviewed by the regulatory agencies having authority to do so. Its publishing here does not reflect approval or disapproval by those agencies.**

The Buffalo District has reviewed the numerous measures to improve the water quality of Onondaga Lake, but because the work is outside the Corps traditional missions, the Corps will not proceed with further study.

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# TECHNICAL ANNEX

Annex A - Water Quality Technical Report

Annex B - Economics

Annex C - Environmental Assessment

Annex D - Bibliography

# 1 - THE STUDY AND REPORT

## 1.1 Introduction

A reconnaissance study was initiated in January 1990 as required by the authorizing legislation. A draft report was completed in May 1991 and was sent to the Corps of Engineers higher headquarters for review. This report was also coordinated with the Onondaga Lake Management Conference. In response to the needs of the Management Conference, this report was revised into the format of a technical report.

## 1.2 Study Authority

This study is authorized by a Resolution of the Committee on the Environment and Public Works of the United States Senate dated June 1989. The resolution states:

*"that the Board of Engineers for the Rivers and Harbors is hereby requested to review reports of the Oswego River Basin, New York, and other pertinent reports, to determine what improvements in the interest of water quality and environmental enhancement are advisable for Onondaga Lake. The study should describe the water quality parameters of Onondaga Lake, examine the interaction between water quality in Onondaga Lake and the Erie Canal, and identify actions and/or improvements to upgrade the water quality of Onondaga Lake to a potable standard. The study should also identify compatible actions and/or improvements for the environmental enhancement of Onondaga Lake."*

## 1.3 Purpose of Study

The purpose of the technical report was to review the existing literature to determine if additional studies are needed to identify the appropriate remedial measures necessary to improve the water quality of Onondaga Lake to allow for its use as:

- a resource for contact recreation;
- a source of consumable fish; and
- a source of drinking water;

No economic benefit analysis is provided in this Technical Report because when this study was initiated, there was no agreed method to measure the benefits. Several proposed methods and procedures for deriving economic benefits are discussed in the Economic Annex.

### 1.4 Scope of Study

The study describes the water quality parameters of Onondaga Lake, examines the interaction between water quality in Onondaga Lake and the Erie Canal, and identifies actions and/or improvements to upgrade the water quality of Onondaga Lake to a potable standard. The study also identifies compatible actions and/or improvement for the environmental enhancement of Onondaga Lake.

This technical analysis of Onondaga Lake consisted of the following investigations:

- Review of data, technical documents and reports prepared by other Federal, non-Federal, and Local agencies;
- Identification of additional sediment and water quality sampling needs;
- Evaluation of the degree of water quality improvements obtainable;
- Identify and assess technologies to manage and treat contaminated sediments; (e.g. dredging, in-situ treatment or control, disposal of dredged material, sediment treatment, and water quality improvements;
- Identify and assess potential solutions for water quality improvements (e.g. combined sewer overflows, upgrade municipal treatment plants, chemical treatment, aeration, or control of upland contaminated deposits affecting water quality);
- Describe the general Socioeconomic characteristics and land use patterns;
- Investigate potential benefit categories; and
- Identify the potential for fisheries and wildlife improvement.

### 1.5 Report Format and Study Process

This study was prepared to be consistent with the planning requirements of the Water Resources Council "Principles and Guidelines" and other related policies, and in accordance with Engineering Regulation 1105-2-100, dated 25 December 1990. This Technical Report consists of a Main Report and a Technical Annex which contains the supporting documentation.

The Main Report summarizes the study's methodology and its accomplishments. The report is written to present the non-technical reviewer and the general reader a clear understanding of the study, the study results, and the key conclusions and decisions

reached. It discusses the resources and economy of the study area, the problems and needs, the measures considered, social and environmental implications of the measures, and a matrix of alternatives. Preliminary cost estimates for the alternatives are shown in tables later in the report.

The Report also includes the following technical Annexes which are bound separate from the Main Report:

- ANNEX A - Water Quality Technical Report
- ANNEX B - Economics
- ANNEX C - Environmental Assessment
- ANNEX D - Bibliography

The supporting documentation contained in the Annexes provides the detailed technical information which supports the conclusions of the Main Report. Annex D contains copies of all correspondence significant to the development of the study.

### 1.6 Studies and Reports by Other Agencies

A large number of studies have been undertaken at the Federal, State and local levels. In addition many studies have been prepared by private contractors, non-profit organizations, and universities. Table I shows some of the current research which is being done to address the problems of Onondaga Lake water quality. Much of the information we have used was drawn from work which was funded by the other members of the Onondaga Lake Management Conference. Clearly this report would not have been possible without their previous efforts. The bulk of the studies are found to be single aspect studies that look at a specific problem or problem source. No studies have been prepared to date that look at the "big picture" or that look at all of the problems and needs or develop a comprehensive plan to coordinate the total cleanup effort.

A comprehensive literature search and review of past studies relevant to the clean up of Onondaga Lake was done by the Buffalo District as an early action item. No new sampling or testing programs were conducted by the Corps of Engineers. The findings and results of each of the available studies have been evaluated by Buffalo District staff. It is expected that more detailed information will become available as more of the ongoing studies are completed.

The public perception seems to be that this lake has been overstudied. Although most of the studies have been single purpose, each is a valuable piece of the total solution. Without the ability to model or understand how a pollutant is getting into the lake, or to understand how it is interacting in the lake, it is impossible to effectively reduce or

Table I - Summary of Current Research Efforts on Onondaga Lake

| Project | Scope | Performed by | Completion Date |
|---|---|---|---|
| Ammonia, Phosphorus, & Nitrogen Modeling | Model effect of inputs on concentration | Upstate Freshwater Institute | 1991 |
| Ammonia Toxicity Assessment | Collect data to calibrate & verify model of ammonia toxicity | NYSDEC & OCDDS | 1988 |
| Bacteria Modeling | Model effects of bacteria inputs on concentrations | UFI | 1989 |
| CSO Abatement | Alternatives for collection, treatment, & discharge of CSOs | Moffa & Assoc. | 1992 |
| Comprehensive METRO Plant Evaluation | Review & analyze design & management to identify performance limiting factors & recommended changes | Stearns & Wheeler | 1992 |
| Transparency Model | Influence of organic & inorganic particulate on Lake clarity | UFI | 1991 |
| Oxygen Model | Effects of external & internal BOD load on dissolved oxygen | UFI | 1991 |
| Lake Monitoring | Collection & analysis of data for substance loading to Onondaga & the lake's responses | OCDDS | Annual |
| Sediment Model | Effects of sediment loads | UFI | 1991 |
| Fish habitat & monitoring | Collection & analysis of fish data on Onondaga Lake | NYSDEC | Annual |

eliminate it.

### 1.7 Study Participants and Coordination

Onondaga Lake in the past several decades has been studied at Federal, State, local, and private levels. The primary agencies or offices that Buffalo District has coordinated with are as follows:

- Federal
  - United States Environmental Protection Agency
  - United States Fish and Wildlife Service
  - Unites States Soil Conservation Service

- State
  - New York State Department of Environmental Conservation
  - New York State Attorney General
  - New York State Parks, Recreation & Historic Preservation

- Local
  - Onondaga County Department of Drainage and Sanitation
  - City of Syracuse
  - Central New York Regional Planning and Development Board

- Private
  - Syracuse University
  - Upstate Freshwater Institute
  - Consultants

In addition to these studies, the Corps has participated as a member of the Onondaga Lake Management Conference (OLMC) and as a member of the Technical Review Committee. Both have assisted in the preparation and review of this report. Their assistance has been valuable in the Corps efforts to gather information and verify data for this report.

### 1.8 Onondaga Lake Management Conference

As a result of a Congressional Authorization (Section 401 of WRDA 90), $500,000 was authorized in fiscal year 1990 to convene a management conference (Onondaga Lake Management Conference). Federal funds were made available under the authority of the Clean Lakes Program, Section 314 of the Clean Water Act. Under the regulations developed for this program, USEPA can award grants only to a State agency designated by the State's Chief Executive (40 CFR Part 35.1610). In this case, the authority has been given to the New York State Department of Environmental Conservation (NYSDEC). The $500,000 grant, accordingly, was awarded to the NYSDEC as Grant Agreement No. S002906-01-0. The NYSDEC is financially accountable for the funds. They contracted with the Onondaga Lake Administrative Services Corporation to conduct the day to day operation of the Management Conference. The State of New York provided matching funds.

The Onondaga Lake Management Conference "shall develop a plan that identifies

corrective action and compliance schedules for cleanup, and coordinate implementation of the plan with the members of the conference and others". The members consist of the Assistant Secretary of Army for Civil Works, the Administrator of the U.S. Environmental Protection Agency, the Governor of the State of New York, the Attorney General of the State of New York, the Onondaga County Executive, and the Mayor of the City of Syracuse. There are two standing committees of the Conference, the Technical Review Committee and the Citizens Advisory Committee. The initial meeting of the Conference was held on February 14, 1990.

The Corps of Engineers has coordinated extensively with the Onondaga Lake Management Conference and its committees during the development of this report. The Commander, North Central Division is the Assistant Secretary of the Army for Civil Works (ASA(CW)) representative on the Management Conference. Buffalo District has a representative on the Technical Review Committee. Portions of this report will be used by the Onondaga Lake Management Conference to develop their "State of the Lake" Report and Management Plan.

### 1.9 Prior Corps Studies, Reports and Projects

There are no prior U.S. Army Corps of Engineers water quality or environmental studies of Onondaga Lake, New York.

Onondaga Lake and its watershed are part of the larger Oswego River watershed. Onondaga Lake has been referenced in general terms in the Final Feasibility Report and Environmental Impact Statement for the Oswego River Watershed, New York, prepared by the U.S. Army Corps of Engineers, Buffalo District. Authorization for the study of feasibility of water resources management in the Oswego River Watershed, N.Y., was provided by a resolution adopted by the House Committee on Public Works, 11 April 1974. The authorization required that the study give consideration to better serve the needs for flood control, urban damage, and lake level control in the Oswego River Watershed.

There have been other studies in the area for the purpose of flood control. Flood control had been a problem in Syracuse since the area was first settled in the marsh areas surrounding Onondaga Lake. The first attempt to improve conditions was made in 1822, when the Outlet of Onondaga Lake was enlarged by local interests, to lower the lake several feet. Since then there has been no serious flooding from Onondaga Lake. Local interests have made numerous channel improvements to Onondaga Creek in the city of Syracuse. A preliminary report, authorized by the Flood Control Acts of 10 April 1936 and 22 June 1936, was submitted 17 April 1937. It recommended surveys be made for the purpose of determining flood control plans for the city of

Syracuse and surrounding localities. The survey report for flood control in the Oswego River Watershed was submitted 15 February 1939 (revised October 1939), recommending that a flood control project be undertaken. The Flood Control Act of 1941 (Public Law 228, 77th Congress, 1st Session) authorized construction of a project to provide flood protection for the city of Syracuse, substantially in accordance with the recommendation of the Chief of Engineers in House Document No. 846.

Two Corps of Engineers projects were later constructed on Onondaga Creek which empties into Onondaga Lake:

> The first project which was authorized by the Flood Control Act approved 18 August 1941 provided for the construction of the Onondaga Creek dam and reservoir (completed August 1949), and the improvement of Onondaga Creek in the city of Syracuse (completed July 1951). The total cost of the completed project was $3,349,248. In addition, it is estimated that local interests incurred a cost of $918,500 for complying with the requirements of the local cooperation agreement.
>
> The second project which was authorized by Section 205 of the Flood Control Act approved 30 June 1958, as amended by Public Law 685, 84th Congress, provided for construction of a new channel alignment for Onondaga Creek, dikes, and erosion protection. Construction of the second project was completed in September 1963. The cost of the completed project was $330,231.

In addition, the U.S. Army Corps of Engineers, Buffalo District has prepared a report of the Syracuse Water Distribution System. This report was completed in 1987.

# 2 EXISTING CONDITIONS

## 2.1 Natural Resources

2.1.1 Regional Area - Onondaga Lake is located in central New York State (reference Figure 1), northwest of the city of Syracuse.


**Figure 1 - Regional Location Map**

Onondaga Lake is located within the Oswego River Drainage Basin, which is tributary to Lake Ontario. The outfall waters from Onondaga Lake flow into the Seneca River which is part of the New York Barge Canal System, then flow east and north into the Oswego River and then flow north into Lake Ontario. The waters enter Lake Ontario at the city of Oswego. Onondaga Lake is part of the New York State Barge Canal system with a canal terminal located on Onondaga Creek, a mile upstream from the

lake.

2.1.2 Study Area - Onondaga Lake is 4.6 miles long and 1 mile wide with a surface area of 4.6 square miles. (reference Figure 2, page 9) It has a mean depth of about 38 feet and a maximum depth of approximately 62 and 64 feet in the north and south basins of the lake, respectively.

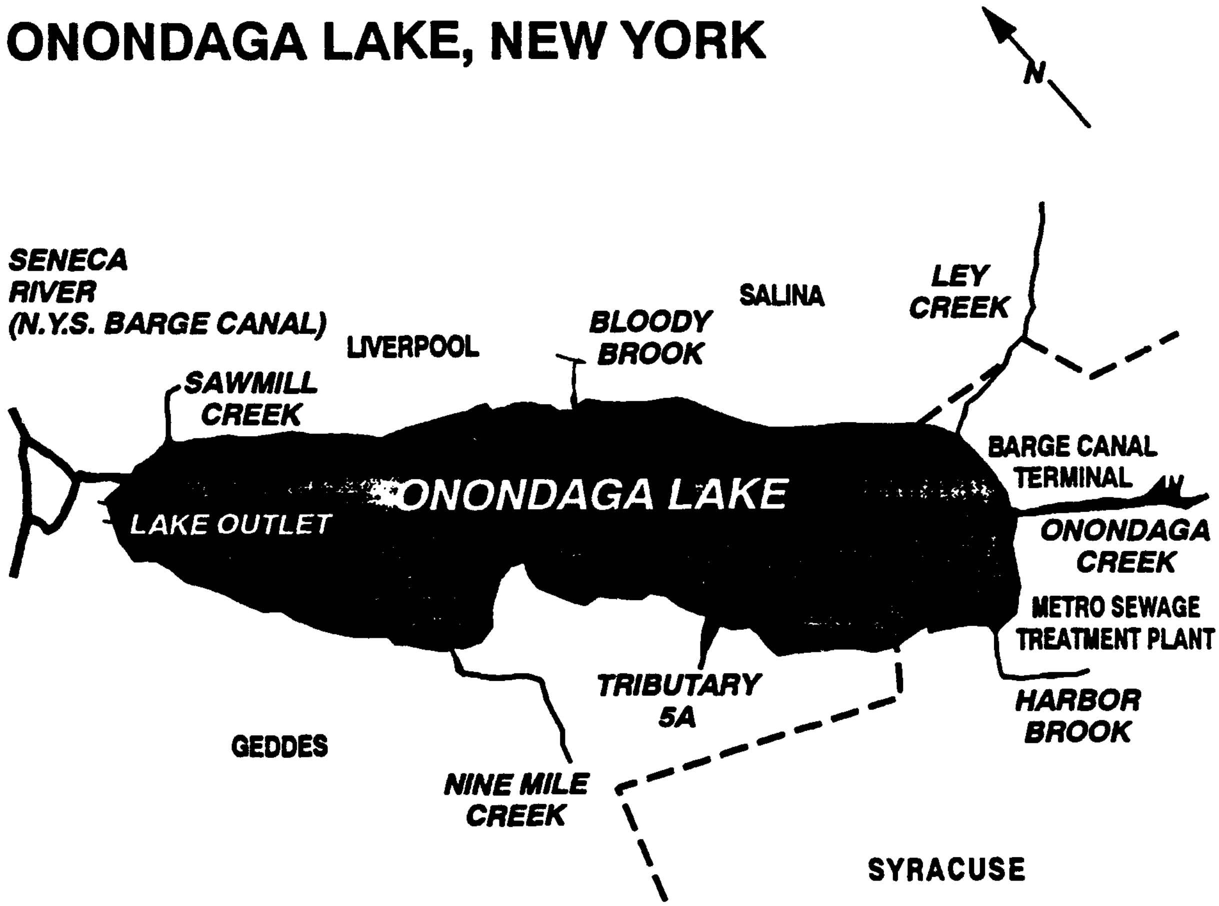



**Figure 2** - Onondaga Lake and Tributaries

The city of Syracuse is located along the south shore of the lake. The major

tributaries of the Onondaga Lake watershed are shown in Table II along with their estimated percentage of contribution to the annual inflow.

**Table II** - Onondaga Lake Tributaries and Average Percentage of Inflow

| Tributaries | Inflow | Drainage (Sq. Miles) |
|---|---|---|
| Nine Mile Creek | 37% | 124.7 |
| Onondaga Creek | 32% | 115.1 |
| Metro Sewage Treatment Plant* | 17% | |
| Ley Creek | 8% | 29.9 |
| Harbor Brook | 3% | 11.3 |
| Sawmill Creek | 1% | |
| Bloody Brook | 1% | 4.5 |
| Tributary 5A | 1% | |

* During the summer months when flows from the tributary creeks are low, the percentage of inflow from the Metro Plant approaches 45 percent.

The study area consists of Onondaga Lake, the outflow of Onondaga Lake, the New York State Barge Canal, and the major tributaries to the Lake. Eighty percent of the shoreline is publicly owned, primarily by Onondaga County.

Upland pollutant sources within the watershed will be identified but will not be investigated nor will cleanup recommendations be made as a part of this study. Furthermore, although private upland waste disposal sites and contaminated land areas may also be contributors to the water quality problems of Onondaga Lake, they were not investigated during this study. Though these upland sources are significant the identification and study of these areas are being conducted by other State and Federal regulatory agencies.

2.1.3 Climate - Onondaga County has a climate classified as humid-continental. The land areas of North America are the primary source of the air masses and weather systems that affect the region. The influence of the Atlantic Ocean is secondary, although it contributes some maritime characteristics to the climate. The areas humid trait arises from the currents of the upper atmosphere which frequently bring moisture from the Gulf of Mexico and the Atlantic Ocean.

Lake Ontario has an important influence on the climate. It moderates the temperature, reducing the occurrence of both hot weather in summer and extreme cold weather in winter. Topography and elevation are factors in producing some

variation of climate within Onondaga County. The hilly terrain and higher elevations in the southern half of the county can cause important differences in temperature and other aspects of climate within relatively short distances.

The summer is pleasantly warm. Maximum daytime temperatures generally range from the upper 70's to the middle 80's. Temperatures of 90° F or higher occur on an average of 3 to 7 days per year. The winters are long and cold with occasional periods of severe weather. The occurrence of below-zero temperatures varies from about 6 days in the northwestern part of Onondaga County to about 12 days in the southeastern part. In most winters, the coldest temperature is between -5° and -20°F. The frost-free growing season averages between 160 and 165 days in the vicinity of Syracuse. It generally is about 175 days in the extreme northwestern part of the county and about 150 days in the southeastern highlands.

Average annual precipitation ranges from 36 inches in the lake plain to 39 to 40 inches in the southern and southeastern border areas of the county. About 45 percent of the annual precipitation is received during the growing season, from May through September. Precipitation is rather evenly distributed throughout the year, about 3 inches per month. It is generally adequate for farming needs and water supplies. Snowfall is heavy throughout the county. Average annual snowfall ranges from 100 to 120 inches in the northern and eastern sections to about 90 inches in southwestern Onondaga County. Total snowfall of 50 inches or more is not uncommon in two successive months.

2.1.4 Physiography - Onondaga County is situated in the center of upstate New York. Because of its location, it borders on several physiographic regions. The county is divided in half by two major physiographic provinces - the Erie-Ontario Plain to the north and the Allegheny Plateau to the south. The demarcation line separating these two provinces is an east-west escarpment formed of Onondaga Limestone.

The northern half of Onondaga County is typified by the Erie-Ontario Plain. Relief in this area ranges from 380 feet to 425 feet above sea level in the lacustrine deposits and from 425 feet to 600 feet on the till plains to the highest drumlins and hills. To the east is the largest part of the Erie-Ontario Plain within the county. It has typical lake-plain topography. Elevations range from 370 feet near Onondaga Lake and Oneida Lake to more than 450 feet on the low hills or ridges of glacial till scattered throughout the plain.

The southern half of the county, beginning at the limestone escarpment, is typical of the northernmost extension of the Allegheny Plateau. Elevations rise abruptly several hundred feet at the escarpment south of Syracuse. Elevation increases to the south, ranging from 600 feet at the northern edge to 1,600 feet. The southern half of the

county has rolling till uplands between deep, U-shaped, steep-sided valleys that extend through the plateau to the south.

2.1.5 Geology and Soils - Nearly all of the parent materials of the soils of Onondaga County were deposited either directly or indirectly through glacial action. Only the recent alluvium of the flood plains is post-glacial.

Bedrock from which the soil material in Onondaga County is derived, is mostly limestone, siltstone, and shale that formed from materials deposited at the bottom of the sea during Silurian and Devonian geologic periods. These sedimentary strata are about 8,000 feet thick over crystalline rocks. The Erie-Ontario Plain in Onondaga County has a high percentage of softer, less resistant shale and limestone of Silurian age. The Allegheny Plateau, except for thick beds of Onondaga Limestone at its northern margin, is mostly inter-bedded shale and thin limestone of Devonian age. Bedrock strata under the Erie-Ontario Plain and the Allegheny Plateau occur in east-west bands having a regional drop southward about 1 degree, or a drop in elevation of 20 to 30 feet to the mile.

The east-west escarpment of Onondaga Limestone generally divides the county into two different regions of both soil and topography - the Erie-Ontario Plain and the Allegheny Plateau.

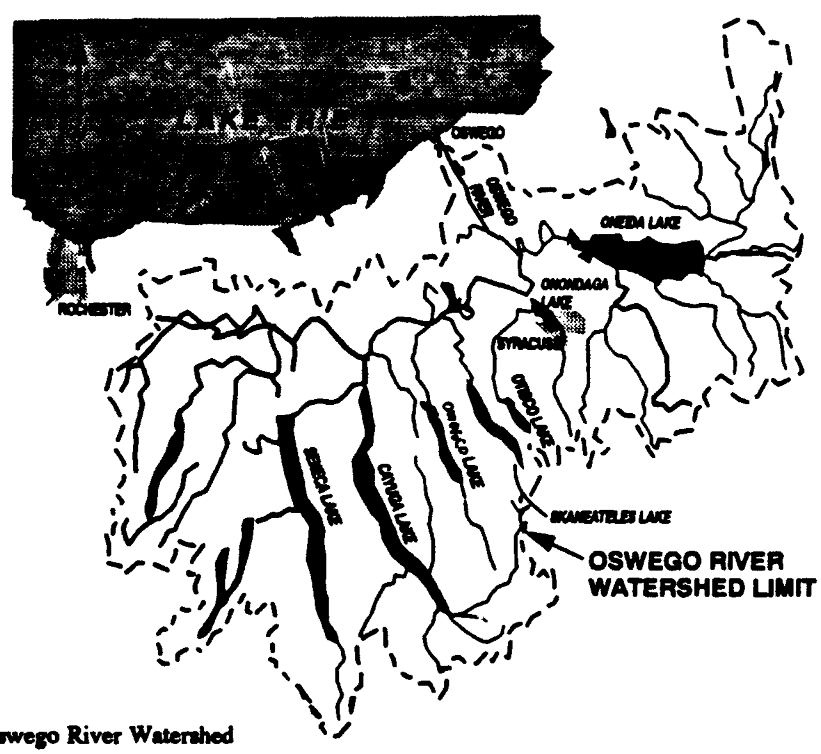



Figure 3 - Oswego River Watershed

2.1.6 Surface Water - The surface waters of the Onondaga Lake watershed, consisting of Onondaga Lake and its tributaries, are in the Oswego River Watershed in central New York State (Reference - Figure 3). A list of the Onondaga Lake tributaries is contained in Table II. The Onondaga Lake watershed has a total drainage area of 245 square miles. It drains into the Seneca River, which has a total watershed drainage area of 3,138 square miles. All of the drainage from Onondaga County eventually flows into Lake Ontario, except for five small watersheds at the southern edge of the county that drain south to the Susquehanna River. The following sub-paragraphs detail the various surface water components that form the study area.

2.1.6.1 Onondaga Lake - Onondaga Lake has a length of about 4.6 miles with an width of about one mile and a total surface area of 4.6 square miles. There is 12.2 miles of shoreline most of which is publicly owned by Onondaga County. The lake has a maximum depth of about 64 feet (19.5 meters) in the south basin and about 62 feet (18.9 meters) in the north basin. Prior to 1822, Onondaga Lake was larger and deeper than it is now. The land area at the south-eastern end of the lake, Oil City, were swamps and marshlands. The desire to create dry lands for development and to decrease the health risks from waterborne diseases (i.e. malaria) was an aim of residents in the early 1800's. Assemblyman Joshua Foreman and others petitioned New York State to lower the level of the lake and thus drain the marshes. In 1822, the level of Onondaga Lake was lowered about two feet when the State dredged the lake's outlet, making it wider and deeper. This action then drained the swampy areas at the south end of the lake and allowed development in this area.

The lake levels are recorded at the NYS Canal Terminal located at the outlet of Onondaga Creek and also maintained at the Onondaga County Metro Sewage Treatment Plant. A report entitled, "Bathymetric Survey and Mapping of Onondaga Lake, New York" dated April 1988, was prepared for the Department of Drainage and Sanitation, Onondaga County by the Upstate Freshwater Institute. This report recorded the results of a field survey of Onondaga Lake, conducted June 20-21, 1987, to determine the water depth throughout the lake basin. The shoreline was not measured during the survey, but was defined by the most recent United States Geological Survey (USGS) quadrangle map. The USGS records indicate a mean lake level of 362.7 ft on June 20, 1987 and a mean lake level of 362.8 ft on June 21, 1987.

Onondaga Lake is surrounded by commercial, industrial, and residential land use. However, a unique feature of this lake is that 80 percent of the shoreline is primarily park lands owned and maintained by Onondaga County with a small portion owned by the City of Syracuse. The private ownership which is entirely industrial/commercial is owned by Conrail, Allied-Signal Corporation, Crucible Steel, and Niagara Mohawk Power Corporation. There is no residential development anywhere along the shoreline.

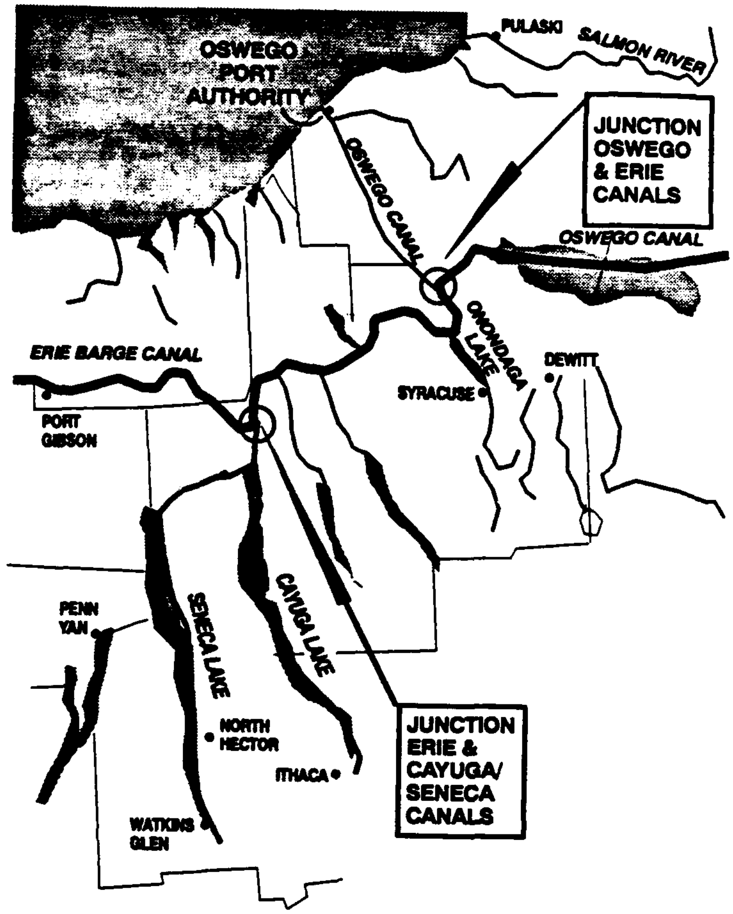



**Figure 4** - New York State Barge Canal System - Onondaga Lake

2.1.6.2 Outlet of Onondaga Lake and NYS Barge Canal System - Onondaga lake is a part of the New York State Barge Canal System as shown in Figure 4. The outlet of Onondaga Lake, is located at the northwestern end of Onondaga Lake and flows into the Seneca River (New York State Barge Canal System) (Reference Figure 5). There are no control structures on Onondaga Lake; however, lake levels are affected by Lock 0 - 1 at Phoenix on the Oswego Canal. The Seneca River flows east from Seneca Lake through Cross Lake to its junction with the Oswego Canal (consisting of the Oneida River which joins to the Oswego River and flows north to Lake Ontario). Construction of the Erie Canal has diverted many parts of the Seneca River. Water levels on the Seneca River are controlled by the canal. There are no requirements to maintain a minimum flow down the Seneca River reach to Cayuga Lake. There is a U.S. Geologic Survey (USGS) gage on the

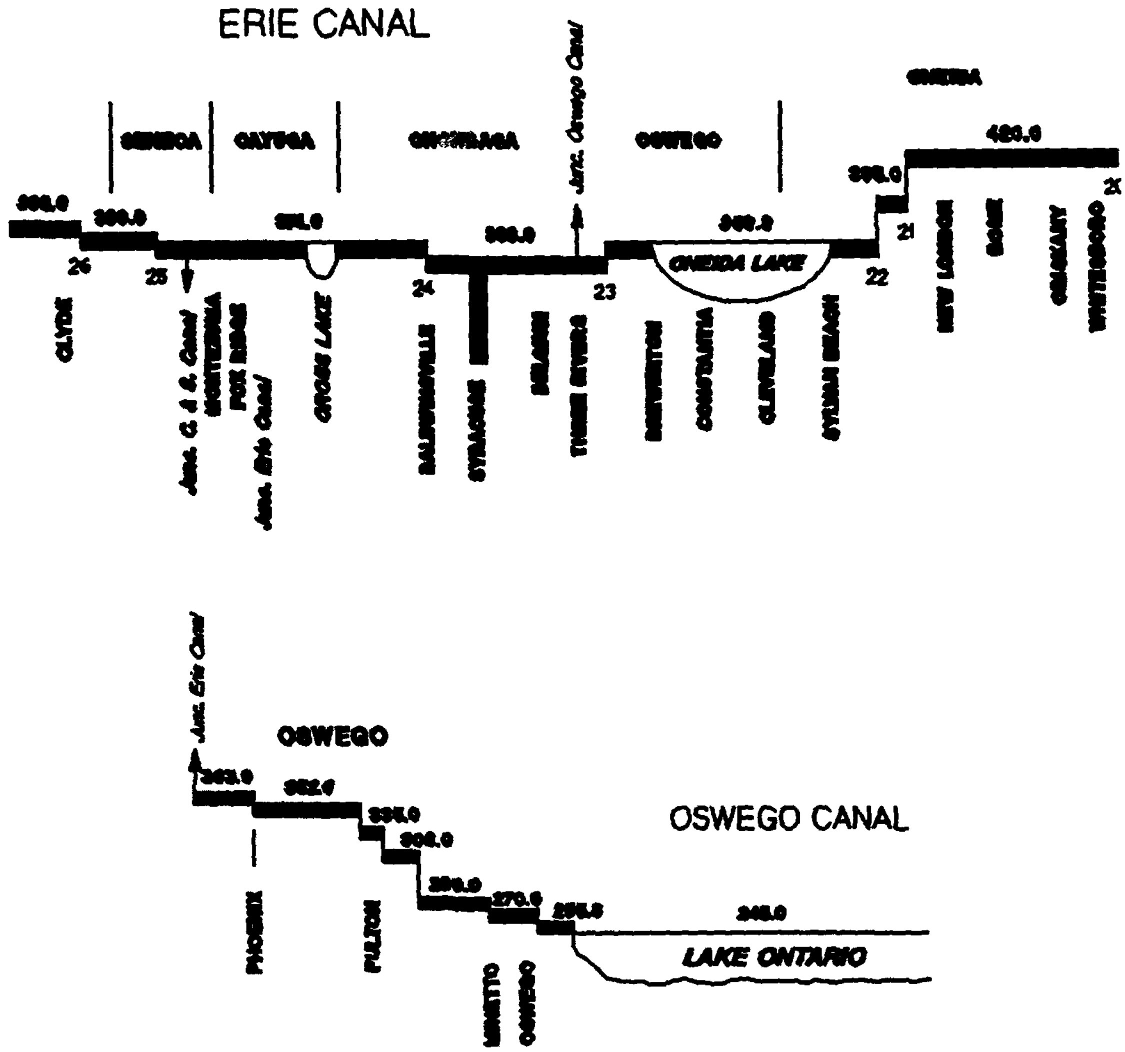



**Figure 5** - Onondaga Lake and the New York State Barge Canal System

Seneca River at Baldwinsville, New York (Lock 24). Recorded peak discharges range from 5960 cfs to 17,200 cfs. The normal pool elevation of the reach between Baldwinsville and the Oswego Canal junction is 363.0 (Barge Canal Survey Datum of the New York State Engineers Survey of 1901). In this reach, boats from the Barge Canal system have free access (no locks) to Onondaga Lake. There is currently a NYS Barge Canal terminal, used for State maintenance purposes, located at the outlet of Onondaga Creek on Onondaga Lake.

As stated previously, Onondaga Lake was lowered in 1822 to drain the swampy areas at the southeastern portion of the lake. This also created an unusual condition whereby the waters from Onondaga Lake and the Seneca River can flow in both directions during the same time period. This phenomenon is being modeled for the Onondaga Lake Management Conference by the Upstate Fresh Water Institute. The results of this modeling will be available in late 1992.

2.1.6.3 Nine Mile Creek - Nine Mile Creek flows through the Towns of Marcellus, Camillus, and Geddes in Onondaga County. The Nine Mile Creek Watershed has a drainage area of 124.7 square miles. (Reference Figure 6 ) Forty-

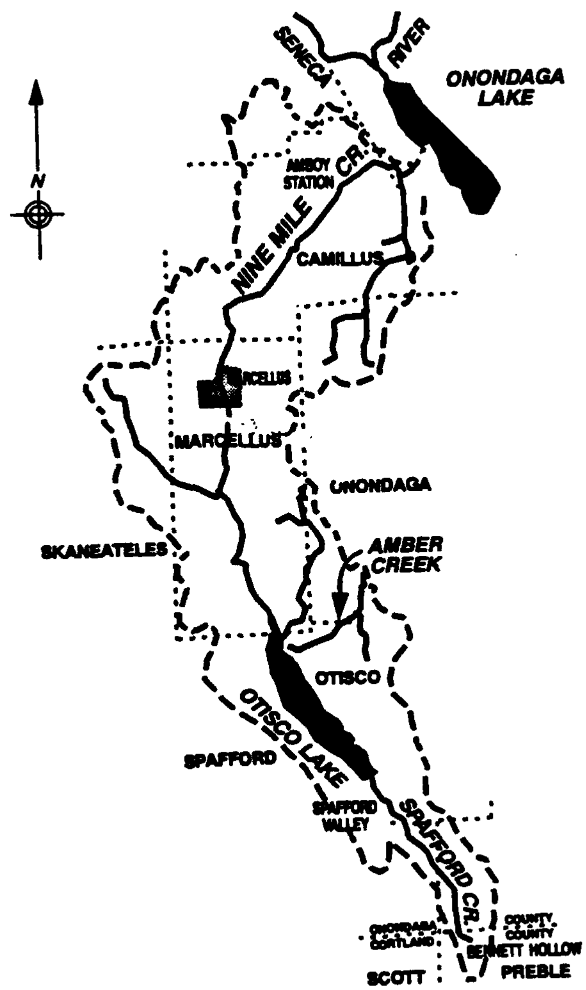



**Figure 6** - Nine Mile Creek Watershed

four square miles of the Nine Mile Creek drainage area lie upstream of the Otisco Lake outlet, which includes the Spafford Creek watershed. Geddes Brook, a tributary of Nine Mile Creek with a total drainage area of 3 square miles, joins Nine Mile

Creek 1.2 miles upstream from Onondaga Lake. Another small tributary discharges into Nine Mile Creek (at mile 6.5) in the Town of Camillus.

The elevation of the highest point in the watershed is 1,915 feet (U.S.C.and G.S. 1929 Adjusted Mean Sea Level Datum) near Bennett Hollow. The lowest point is 363 feet at south central portion of Onondaga Lake. Nine Mile Creek from a point 10 miles upstream to the Lake has a drop of 68 feet representing an average stream slope of 6.8 feet per mile.

Flow is regulated in Nine Mile Creek at Otisco Lake by an earthen and concrete dam. Water is also diverted from Otisco Lake for the water supply purposes of the Regional Water Authority. A earthen and concrete dam is located at Otisco Lake. The maximum recorded discharge of 2,760 cfs at the Camillus gaging station occurred on March 30, 1960. The narrow flood plain of Nine Mile Creek is developed with scattered residential communities and some small industries (about 10 % urban land use). The remainder of the watershed area is made up of forest land use (25%) and agricultural or idle land.

2.1.6.4 Onondaga Creek - Onondaga Creek is tributary to Onondaga Lake and is part of the Oswego River watershed in central New York. (Reference Figure 7) The stream is formed by the junction of the west and south branches about 1,700 feet upstream of the Corps of Engineer's dam. The main stream then flows north through the city of Syracuse and empties into Onondaga Lake at the north-western edge of the city, 13.2 miles downstream from the dam. The length of Onondaga Creek plus its south branch is 27.2 miles. The total drainage area of the creek is 115.1 square miles, of which 68.1 square miles lies above the dam. The watershed is a mix of agricultural land use in the Tully Valley, with urban and industrial land use in the city of Syracuse.

Elevations with respect to mean sea level vary from 364 feet at the mouth to 1,887 feet at Dutch Hill near the southern end of the watershed. Below the junction of the two branches the stream has a uniform slope of about 7 feet per mile. Upstream from the junction, for a distance of about 6 miles on the south branch and four miles on the west branch the streams have slopes of about 14 feet per mile. In the upper reaches of the two branches the slopes become steeper, ranging up to 500 feet per mile. The valley varies in width from 1/2 to 1 mile with the exception of a relatively narrow section extending about 1/2 mile downstream from the junction of the two branches, and a narrow gorge extending about 1 mile downstream from the southern edge of the Indian Reservation. The valley sides rise 500 to 1,000 feet above the stream,some slopes having a 50 percent grade. There are no lakes or permanent reservoirs in the Onondaga Creek watershed, although a pool will form behind the Corps of Engineers dam during flood stages. This dam, completed in 1949, is located about 4 miles south of the City of Syracuse on the Onondaga Indian Reservation. The reservoir has

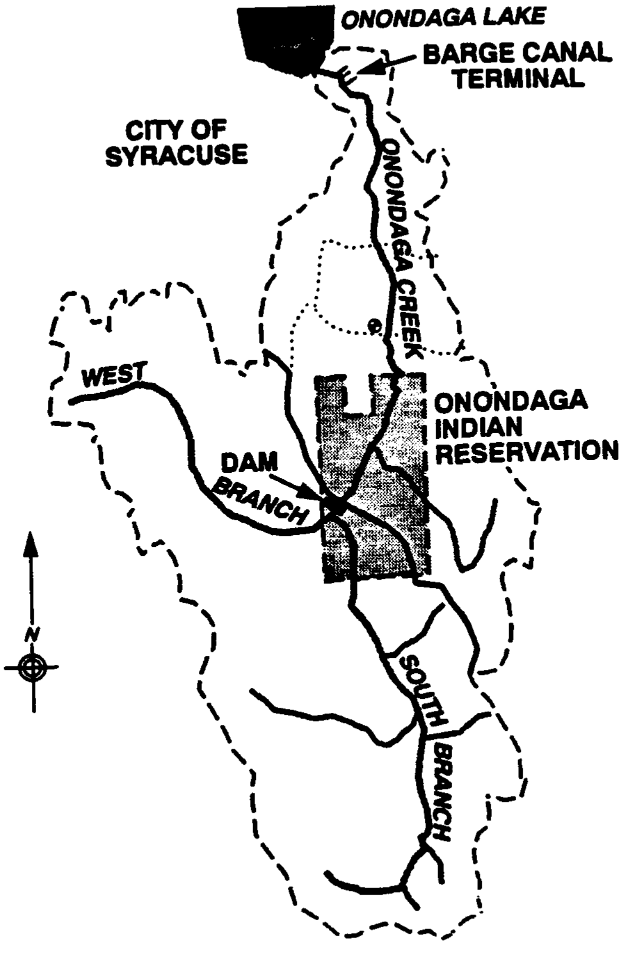



Figure 7 - Onondaga Creek Watershed

a capacity of 18,200 acre-feet at spillway crest. In addition, a flood control project was completed by the Corps of Engineers in 1963. This channelization project constructed dikes and realigned the creek from Dorwin Avenue to the northern boundary of the Onondaga Indian Reservation. The largest recorded flood occurred in March 1920 with a flow of 6,000 cfs.

2.1.6.5 Ley Creek - Ley Creek flows in a westerly direction from the junction of North and South Branch to its mouth at the western portion of Onondaga Lake near the Syracuse city line. Ley Creek with its five major tributaries (Bear Trap Creek, North Branch, South Branch, Sanders Creek and Teall Brook) drain an area of 29.9 square miles. (Reference Figure 8) Seventy percent of the watershed has been developed for industrial, commercial and residential uses. The remainder, in the upstream reaches, is primarily idle land, with only 5 percent agricultural. The topography of the Basin is generally flat with some gently rolling hills. Surface

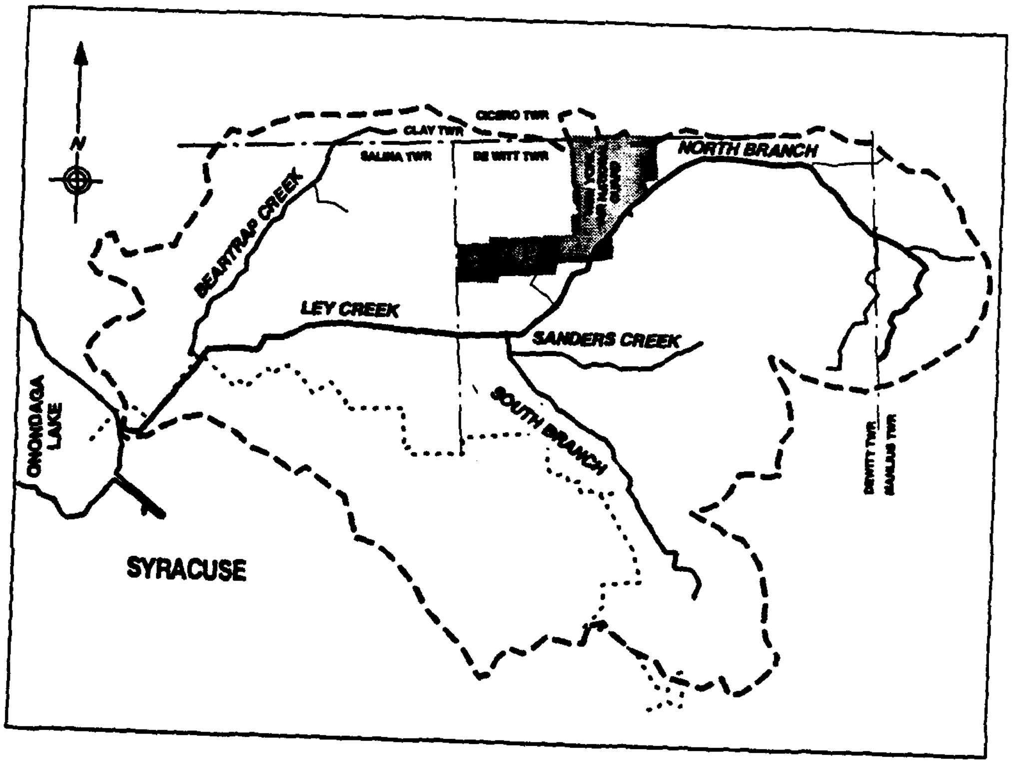



Figure 8 - Ley Creek Watershed

elevations vary from about 410 feet at the headwaters of the basin to about 363 feet at Onondaga Lake. The stream bed gradients are very mild, varying from about 5 feet per mile to about 1 foot per mile. The USGS gaging station is rated poor due the backwater affect from the lake. It is estimated that a 100-year flood would have a discharge of 2,000 cfs.

2.1.6.6 Harbor Brook - Harbor Brook, which enters Onondaga Lake at the southernmost point of the Lake, drains a watershed of about 11.3 square miles. The upstream watershed is primarily rural, while the lower reaches run through the urban areas of Syracuse.

2.1.6.7 Sawmill Creek - Sawmill Creek, is a small tributary that drains a wooded marsh land located in the Onondaga County park at the north end of Onondaga Lake. The outfall for Sawmill Creek is located approximately one mile to the east of the Onondaga Lake Outlet. The watershed is small and has only a slight

slope. The watershed drains a primarily low density residential, recreational, and natural wetland areas.

2.1.6.8 Bloody Brook - Bloody Brook, is a small tributary that drains an urban area of the Town of Liverpool. The Brook flows into Onondaga Lake at the north central portion of the Lake, less than a mile southeast of the Yacht Club marina basin or about 2.25 miles southeast of the Lake's outlet. Bloody Brook has a watershed area of 4.5 square miles.

2.1.6.9 Tributary 5A - Tributary 5A enters Onondaga Lake about 0.8 miles northwest of the city of Syracuse line on the west shore of the Lake. This tributary receives treated waste water from Crucible Steel, a steel manufacturing industry. The flow to Onondaga Lake is relatively low.

2.1.6.10 East Flume - The East Flume is actually an industrial discharge from Allied Chemical Corporation. During the operation of Allied, water was removed from the lake, treated, and circulated through the facility for cooling purposes. The waste heat water was discharged into the East Flume. Since the closure of Allied, the average temperature in the East Flume has decreased. Gage data is unreliable due to the backwater affect of the lake.

2.1.7 Groundwater - Stratified-drift deposits that underlie flood plains and terraces along larger valleys generally form the most important aquifers. In upstate New York, glacial- lake and beach sand in upland areas also may contain significant aquifers. Bedrock is only a significant aquifer in the sandstone and carbonate rock formations across the State. The major use of groundwater in upstate New York is for public and domestic drinking water supplies. Virtually all rural residents of upstate New York, obtain their drinking water from private domestic wells, some of which have significant yields from stratified drift deposits and bedrock aquifers, but most from low-yielding aquifers that underlie most of upstate New York. Groundwater in most areas of New York State is of good quality and suitable for most uses.

Groundwater in the Syracuse/Onondaga Lake area, from the stratified drift deposits and shallow bedrock aquifers, yields slightly to moderately saline water. Contamination of ground water supplies in the Syracuse area is a concern due to the potential for infiltration of pollutants from area chemical waste beds and land fills. Groundwater supplies for domestic and farm use in Onondaga County are generally adequate from both soils and bedrock. Large supplies of groundwater for municipal and industrial use, however, are located only in a few selected areas in the county, mainly in the sand and gravel aquifers in major stream valleys. Even though these large supplies are available, the possibility of contamination by salt water renders them useless for most considered possibilities.

2.1.8 Water Quality - Surface waters in New York State are classified according to the intended best use. Water quality standards have been developed to protect these best uses. The classifications and standards are contained in Part 701, Chapter 10 of the New York Code of Rules and Regulations (NYCRR). The New York State fresh waters are classified AA, A, B, C, and D. Table III outlines the "Best Usage of Waters" for each of the classifications. Most of the waters flowing in and out of Onondaga Lake are Class "B", "C", or "D".

**Table III** - NYS Water Quality Classifications - Best Usage

| Classification | Best Usage of Waters |
|---|---|
| Class "AA" | Source of water supply for drinking, culinary or food processing purposes and any other usages. |
| Class "A" | Source of water supply for drinking, culinary or food processing purposes and any other usages. |
| Class "B" | Primary contact recreation (swimming) and any other uses except as a source of water supply for drinking, culinary or food processing purposes. |
| Class "C" | Suitable for fishing and all other uses except as a source of water supply for drinking, culinary or food processing purposes and primary contact recreation. |
| Class "D" | These waters are suitable for secondary contact recreation, but due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery or stream bed conditions, the waters will not support the propagation of fish. |

Note: The waters of Onondaga Lake and its tributaries may be further restricted than these classifications due to specific localized conditions that limit safe usage of their waters.

The current water quality condition of Onondaga Lake and its tributaries was further ascertained from monitoring and testing results. The Onondaga County Department of Drainage and Sanitation has been monitoring five tributaries to Onondaga Lake as part of their annual monitoring program. In addition to the five natural tributaries (Onondaga Creek, Nine Mile Creek, Harbor Brook, Ley Creek, and Tributary 5A), the lake outlet, intake for industrial water at Allied, East Flume, and the outfall from the Metropolitan Sewage Treatment Plant are part of the monitoring program. The primary pollutants to the lake originating from the tributaries are summarized in Table IV.

**Table IV** - Contributing Pollutants from Tributaries of Onondaga Lake

| TRIBUTARIES | MAJOR POLLUTANTS | SOURCES |
|---|---|---|
| Nine Mile Creek | Inorganic Salts (sodium, calcium, chloride)<br>Zinc, Lead, Copper, Chromium, Cadmium, Mercury | Treated Waste water Outfalls<br>Chemical Industries |
| Onondaga Creek | Fecal Coliform Bacteria<br>Salts<br>Lead<br>Copper<br>Chromium<br>Phosphorus<br>Sediment Loadings | Combined Sewer Outfall's<br>Industries<br>Groundwater<br>Mud Boils |
| Ley Creek | Fecal Coliform Bacteria<br>Ammonia Nitrogen<br>Organic Nitrogen<br>Total kjeldahl Nitrogen<br>Phosphorus<br>Organic compounds | CSO's<br>Pump Station overflows<br>Landfills |
| Harbor Brook | Fecal Coliform Bacteria<br>Ammonia Nitrogen<br>Inorganic Carbon<br>Particulate Organic Carbon<br>Copper, Lead | CSO's<br>Pump Station overflows<br>Chemical Industries |
| Sawmill Creek | Negligible | |
| Bloody Brook | Negligible | Coolant Waste Waters |
| Tributary 5A | Iron<br>Chromium, Copper | Steel Industry (waste water treated since 1974) |
| East Flum[illegible] | Ammonia, Nitrite, Nitrate | Chemical Industries |

Onondaga Lake has received the discharge of municipal effluent and industrial waste for the past century, and this has resulted in a polluted lake that is hyper-eutrophic. The transparency is generally poor (less than 4 feet visibility) because of high concentrations of phytoplankton, calcium carbonate and suspended solids. The high phytoplankton concentration occurs as a result of high nutrient loadings, particularly phosphorus. Sources of phosphorus include the METRO sewage treatment plant, combined sewer overflows, internal recycling from bottom sediments, and non-point sources. Calcium carbonate production in the lake has been enhanced by elevated

calcium concentrations from the direct discharge of landfills and seepage of Ionic waste from the adjoining waste beds of an alkali manufacturer. High fecal coliform bacteria cause restrictions in contact recreation. The fecal coliform (DOH) standards are frequently violated after heavy storms when the runoff exceeds the capacity of the combined sewers and spills raw sewage out the over flows. The fishery is impacted by mercury contamination of fish flesh, inadequate dissolved oxygen, and the destruction of the habitat. The fish may also be affected by high ammonia concentrations in the lake. The problem with the oxygen depletion is so severe during the summer that concentrations adequate to support fish are often limited to the upper 20 percent of the water column. During the fall, the New York State standard for dissolved oxygen (5mg/l minimum daily average) is violated because material that has settled on the bottom of the lake during the summer is brought to the surface and consumes the remaining oxygen. Table V compares the current conditions of Onondaga Lake with the appropriate water quality standards for each goal.

The primary nutrients of concern in Onondaga Lake are phosphorus and nitrogen. Management efforts have been directed at trying to make phosphorus the limiting nutrient to algae growth. Efforts to control ammonia must be concerned with the phosphorus to nitrogen ratio to prevent conditions that would be favorable to nuisance blue-green algae growth.

*Section 3 of this report will expand upon the specific water quality problems.*

**Table V** - Comparison of Current conditions with State Water Quality Standards

| Parameter | Existing 1989 Peak/Average | Swimming Goal | Cold-fishing Goal | Drinking Goal |
|---|---|---|---|---|
| Secci Depth | 3.3'/5.2' | 4.0' | | |
| Total Coliform | 251/na | <2400/100ml | | |
| Fecal Coliform | na | 200/100mg | | |
| Ammonia (mg/l) | 6/3 | - | 2.06 | 2.06 |
| | | | 0.27 | |
| DO (mg/l) | 0.0/7.5 | - | 6 | 5 |
| Mercury (mg/l) | na/.2ppb | - | <0.0002 | <0.002 |
| | | | - | <0.005 |
| Nitrite (mg/l) | 0.72/0.182 | - | 0.02 | 10 |
| Nitrate (mg/l) | 5.0/1.49 | - | - | 10 |
| Sodium (mg/l) | 255/200 | - | - | <20 |
| Calcium (hypolimnion) (mg/l) | 190/159 | - | - | - |
| Zinc (hypolimnion) (mg/l) | 0.065/0.024 | - | 0.03 | <0.3 |
| | | | - | 5 |
| Cadmium (hypolimnion) (mg/l) | .013/.003 | - | - | <.01 |
| Copper (mg/l) | .07/.020 | - | - | <.2 |
| | | | - | 1 |
| Chloride (mg/l) | 510/458 | - | - | 250 |

# 3 - PROBLEM IDENTIFICATION

### 3.1 Introduction

The major water resource problem associated with the lake is the degraded water quality. The poor water quality deters optimal use of the lake, affects fish and wildlife resources, and stymies the potential for redevelopment and economic growth in the surrounding area.

### 3.2 Problems, Needs, and Opportunities

3.2.1 Water Quality Problems - The primary water quality problems and causes at Onondaga Lake are shown in Table VI. The major problems are high concentrations of chlorides, sediments, fecal coliform, mercury, dissolved oxygen depletion, phosphorus, and nitrogen. While other pollutants (heavy metals and organic compounds) are present in the lake and tributaries, the significance of these contaminants has not been thoroughly analyzed.

The actions listed under each goal only define the major parameters that need to be changed not the measures that must be taken to reach these goals. The State of New York and the U.S. Environmental Protection Agency have standards for hundreds of water quality parameters. However, the concentrations of the other pollutants for Onondaga Lake are considered low enough as not to warrant addressing them in this section. In sections 3 and 4 of Annex A, the Water Quality Technical Annex, the pollutants and their concentrations at select specific sampling periods are presented in greater detail.

3.2.2 Environmental Enhancement Needs - The authorization for this study states that this study will identify compatible actions and/or improvements for the environmental enhancement of Onondaga Lake. Environmental considerations were investigated under two broad categories: community/regional development and natural environmental enhancement.

Community and regional environmental enhancement would be similar to the on-going projects that are being developed by local planning agencies. The plan is to integrate these into a more comprehensive set of Corps of Engineers alternatives which addresses water quality and environmental enhancement. With so much of the shoreline in Public ownership, the potential recreational developments could include improvements to swimming beaches/facilities, boating marinas, and fishing facilities.

Table VI - Onondaga Lake Water Quality, Problems & Causes

**ONONDAGA LAKE**
**WATER QUALITY PROBLEMS AND CAUSES**

| WATER QUALITY PROBLEMS | CAUSES OR SOURCES | CONSEQUENCES |
|---|---|---|
| Dissolved Oxygen (DO) depletion in hypolimnion | Hypereutrophic from high nutrient loads/levels | Cannot maintain cold water fishery<br>Excessive nutrient, metals leaching from sediments<br>Production hydrogen sulfide and methane gases<br>High ammonia concentration |
| Excessively high phosphorus loads/levels | Discharges from the Metro Sewage Treatment Plant and CSO's | High algae productivity<br>Algae decay depletes DO<br>Creates high sediment oxygen demand<br>Decrease transparency |
| Excessively high nitrogen loads/levels | Discharge from the Metro Sewage Treatment Plant | High Algae productivity<br>Ammonia toxicity<br>Nitrite toxicity<br>Decrease transparency<br>Algae decay depletes DO |
| High chloride concentrations in water | Former industrial discharges and leaching from waste beds | Contravenes state standards for fishery and drinking |
| Sediments discharge from Onondaga Creek | Tully Valley Mud Boils | No fishery below mud boils<br>Decreased lake transparency |
| High fecal coliform loads during storm events | Combined Sewer Outfalls (CSO's) | Contravention of state swimming standards |
| High mercury levels in sediments | Former industrial discharges | High concentrations accumulated in aquatic life |

In addition to the goals of fishing, swimming, and drinking, the OLMC has set an additional goal to have Onondaga Lake aesthetically pleasing.

Under the second category, potential natural environmental enhancement can only be developed if the water quality of Onondaga Lake is improved. Therefore, to address this need, the plan is to formulate alternatives which improve the fish and wildlife habitat in the Onondaga Lake area.

3.2.3 Pollutant and Nutrient Sources - The pollutant and nutrient loadings come from a variety of sources. With the settlement and development of urban areas around Onondaga Lake the pollution to the lake has increased. For more than a century, the Lake has been a receptacle for industrial waste, raw sewage, and other pollutants. The following paragraphs describe the sources of these pollutants. Additional technical details can be reviewed in the Water Quality Annex of this report.

3.2.3.1 Onondaga County Metropolitan Sewage Treatment Plant - The Onondaga County Metropolitan Sewage Treatment Plant (METRO) contributes a significant pollution load to the lake.
The impacts of METRO are a major part of the current research, monitoring, and modeling effort. METRO was upgraded to provide secondary treatment and more effective disinfection in 1979. The plant was upgraded again in 1981 to provide tertiary treatment in an attempt to further reduce the total phosphorus loading to the Lake. Despite these improvements in recent years, the effluent from METRO continues to impact on the following water quality parameters:

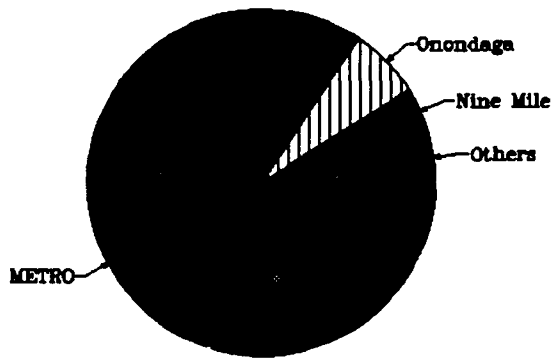


**Figure 9** - Distribution of Phosphorus Entering Onondaga Lake by UFI, June to August 1987

(1) Carbon species, including biochemical oxygen demand (BOD), total organic carbon, filtered total organic carbon, total inorganic carbon and total alkalinity.

(2) Silicon dioxide

(3) Phosphorus, both total inorganic phosphorus and orthophosphate.

(4) All monitored forms of nitrogen, including ammonia nitrogen, organic nitrogen, total kjeldahl nitrogen, filtered total kjeldahl nitrogen, nitrate nitrogen, and nitrite nitrogen.

(5) Several heavy metals including zinc, lead, copper, chromium, and cadmium.

The closure of the Allied Chemical Corporation's Chlor-alkali facility in 1986 dramatically decreased the concentrations of sodium chloride and calcium chloride, and redı  ·d the specific conductance in the METRO effluent.

3.2.3.2 Combined Sewer Outfalls (CSOs) - The combined sewers are a major source of contaminants to Onondaga Lake. In the Syracuse area, new residential, commercial, and industrial developments have resulted in increased loadings of sanitary waste water and storm water. This has impacted adversely upon

the limited capacity of the existing combined sewer system, resulting in direct discharges in streams tributary to Onondaga Lake. There are 45 CSO's that discharge into Onondaga Creek, 19 CSO's that discharge into Harbor Brook, and 2 CSO's discharge into Ley Creek. The CSO's are direct sources of fecal coliform, biochemical oxygen demand (BOD), nitrogen, heavy metals, phosphorus and a variety of toxic pollutants discharged to the combined sewer by industrial users of the collection system. Onondaga County is currently conducting investigations to reduce the number of CSO's.

3.2.3.3 Industries - Onondaga Lake over the past century has encouraged industrial development along the southern shoreline because the Lake has been a ready source of process water and a receiving body for process wastes. The major industries, that are significant industrial dischargers, are listed in Table VII.

**Table VII** - Significant Industrial Dischargers

| Significant Industrial Dischargers |
|---|
| Crucible Specialty Metals |
| Bristol-Meyers Squibs |
| GMC Fisher Guide Plant |
| Carrier Corporation |
| Oberdorfer Foundries |
| Sun Refining and Marketing |
| Chrysler Corporation |
| Syracuse China Corporation |
| Roth Brothers Smelting Corporation |
| Otisco Lake - Water Treatment Plant |
| General Electric |

Note: Allied Chemical and Linden Chemicals & Plastics, which closed in 1986 & 1988 respectively, were significant discharges. The significance of their residual discharges has not been determined.

These industries discharge into the tributaries of Onondaga Lake, either directly or through municipal sewage treatment plants. In addition, about 400 smaller scale businesses and industries discharge waste waters into the Onondaga County Metropolitan sewer system. These discharges are regulated under the County's Department of Drainage and Sanitation industrial waste water pretreatment program.

Historically the industries that have had the most significant loadings to Onondaga Lake have been Allied Chemical Corporation, Crucible Specialty Metals, and Linden

Chemicals and Plastics (LCP). Allied also used a mercury cell technology to manufacture chlorine. This produced discharges of mercury in 1970 at estimated levels of 0.5 to 21 lbs/day. In 1977 Allied installed the EPA prescribed treatment system which used alkaline sulphide to precipitate out the mercury. The mercury was then disposed of in a hazardous waste disposal facility. Allied also operated a plant that manufactured chlorinated benzene with a muriatic acid by-product at its 34 acre plant site located at Willis Avenue and State Fair Boulevard in the Town of Geddes from 1918 until it closed in 1977. Some chloro-benzene is suspected to have entered the ground water and migrated to the lake.

From 1917 until 1970, Allied and its predecessor company (LCP) manufactured a variety of organic chemicals at the Allied site in Solvay, N.Y. Byproducts of this operation were stored in lagoons, that were built upon some of the original Solvay waste beds.

During June 1991, researchers conducting sampling in Onondaga Lake discovered thick veins of a black tar-like substance in the sediment layers in an isolated area on the south-east side of the lake. The source of deposit is yet to be determined.

Crucible Specialty Metals is a steel foundry and rolling mill that had discharged levels of iron, chromium, and copper in its waste cooling waters. On-site pretreatment (in-place since 1974) has significantly reduced the level of metals entering Onondaga Lake.

3.2.3.4 Onondaga Lake - According to the State Code, Onondaga Lake is classified as a Class B and Class C body of water. NYSDEC testing has established that the lake's western end is in better condition than the eastern portion. This is primarily due to the discharges of METRO and the material coming out of Onondaga Creek. A detailed description of where the classification changes is given in Annex A. These classifications for Onondaga Lake do not correspond with an objective picture of the condition of the lake. Swimming has been banned since 1940 due to high bacterial counts and turbidity. In 1970 fishing in Onondaga Lake was prohibited. Today sport fishing is allowed on the Lake, but the public is warned not to consume the fish due to contamination and high concentrations of mercury. Above all Onondaga Lake is not suitable as a source of drinking water.

3.2.3.5 NYS Barge Canal Water Quality - Although the NYS Barge Canal system extends 524 miles across New York State, it is not a major source of drinking water. For a body of water to be used as a public water supply it must be classified as Class AA or Class A. Onondaga Lake enters the NYS Barge Canal system at river mile 167.8 which is a class B reach as shown in the shaded area to the right.

The Upstate Freshwater Institute is conducting an evaluation study of the interaction

between the Seneca River and Onondaga Lake to establish a hydrologic budget for the Lake.

| *Barge Canal Reach* | *Class* |
|---|---|
| *129.5 - 189.2* | *B* |
| *108.1 - 129.5* | *C* |
| *189.2 - 210.9* | *C* |
| *201.9 - 204.7* | *D* |

*Water Quality, NYS Barge Canal*

3.2.3.6 Nine Mile Creek - Nine Mile Creek receives treated waste water from the Village Marcellus, as well as overflow and infiltration from the Allied Chemical Corporation waste beds. This creek is the largest tributary source of inorganic salts (sodium, calcium, and chloride) to Onondaga Lake. Results from the 1988 data collection showed elevated concentrations of zinc, lead, copper, chromium, cadmium, and mercury. The average mass loading rate of mercury for 1988 was 0.632 pounds per day. Nine Mile Creek also contributes 4.2 percent of the total phosphorus to the lake (the fourth largest contributor).

3.2.3.7 Onondaga Creek - There are a total of 45 combined sewer overflows that discharge into the creek. Based on recent monitoring data (1988), the quality of the Creek is degraded (see shaded area to right) with elevated concentrations of fecal coliform bacteria, salts, and heavy metals (lead, copper, and chromium). Due to the large volume of flow from Onondaga Creek, it is a major contributor of these pollutants into Onondaga Lake. Onondaga Creek is also the second greatest contributor of phosphorus, surpassed only by the Metro Sewage Treatment Plant. As a result, the water quality at its mouth is classified as 'Class D'.

| *Location* | *Class* |
|---|---|
| *US to Temple St* | *D* |
| *Temple to Trib. 5B* | *C* |
| *5B to US limit* | *B* |

*Water Quality Classification, Onondaga Creek*

Large sediment loads have been identified to be originating from the southern Tully Valley in an area referred to as the "Mud Boils". The large sediment load from the "Mud Boils" is also adversely affecting the fishery in lower Onondaga Creek.

3.2.3.8 Ley Creek - The NYS water quality classification designation for Ley Creek from its mouth upstream to the Ley Creek Sewage Treatment Plant outfall is Class "D". From the sewer outfall upstream to the South Branch, Ley Creek has a classification of Class "B". Two combined sewer outfalls (CSO's) enter Ley Creek. Two closed sanitary landfills are located adjacent to Ley Creek and may be contributing varying amounts of organic materials to the stream.

3.2.3.9 Harbor Brook - The Brook receives discharges from 19 CSO's and overflows from the Hillcrest and Brookside pump stations. Results from the 1988 monitoring program show elevated concentrations of total inorganic carbon, particulate organic carbon, copper, and lead. Although it is a Class D stream at its mouth, Harbor Brook contributes a relatively small percentage of the total load to Onondaga Lake. Concentrations of these parameters entering the lake are likely to be higher during storm events which impact upon the combined sewer outfalls.

| *Location* | *Class* |
|---|---|
| *Mouth US to Gifford* | *D* |
| *Gifford US to City line* | *B* |
| *City line US to* | *C* |

*Water Quality, Harbor Brook*

3.2.3.10 Sawmill Creek - Sawmill Creek from its mouth upstream to Euclid Road, has a classification of Class "B" and from Euclid Road to the Creek's source it is Class "D". The watershed is very small and receives no significant pollutant point sources.

3.2.3.11 Bloody Brook - From the mouth of Bloody Brook for a distance of 0.4 miles upstream, the classification is Class "B". The remainder of the brook is classified Class "D". The tributary receives no significant pollutant point sources with the exception of some treated coolant and waste waters from the General Electric Corporation's Park complex.

3.2.3.12 Tributary 5A - This tributary has no NYS water quality classification. This tributary receives treated waste water from Crucible Steel. Tributary 5A has historically contributed iron, chromium, and copper to the Lake. Prior to 1974, these metals were not treated; however, the construction of an industrial waste water reuse and treatment plant has resulted in significant reductions in loading as demonstrated in the results of the 1988 monitoring data.

3.2.3.13 East Flume - The East Flume was an industrial discharge point for Allied Chemical Corporation and a variety of other industries. Some of the data from the 1988 monitoring survey showed lower concentrations in the East Flume than in the lake. However, the 1988 monitoring data does indicate that ammonia, nitrite, and nitrate are contributed to the lake from the activities of the remaining industries.

3.2.3.14 Waste Disposal Sites - Waste disposal sites and hazardous waste sites are located along the southwestern and southeastern shoreline of Onondaga Lake and immediately upland. No waste sites have been observed or recorded along the northwest or northeast areas of the Lake. Figure 10 and Figure 11 show the locations of the Allied Waste Disposal Sites and Hazardous Waste Disposal Sites, respectively. The State of New York is currently taking a number of legal actions against the major

sources of sewage and industrial waste. The information on these sites presented in this section is current as of the date of this report. The following paragraphs describe the waste disposal sites in the area.

(1) Allied Waste Disposal Sites - The Allied waste disposal beds (Solvay waste beds) have been and continue to be one of the significant sources of pollutants to Onondaga Lake. The oldest beds are located along the shores of Onondaga Lake from the mouth of Nine Mile Creek south to the southwest end of the Lake. The younger and larger beds are located upland along Nine Mile Creek. The primary waste materials deposited in these beds are the wastes resulting from the Solvay process: calcium carbonate, calcium silicate, magnesium hydroxide with some carbonate, sulfate salts, and metal oxides. During periods of peak production (prior to 1986 when the Solvay plant was operating) up to 500 tons per day of waste products were produced. This waste material was comprised of a slurry of 5 to 10 percent solids. The solids were settled out in the waste beds and the relatively clear supernatant was discharged to surface waters through drop inlets and circumferential collection system. Evidence of this same waste material can still be found in the lower reach of Nine Mile Creek and in Onondaga Lake. The waste material is 4 to 6 feet deep in various areas in the lake.

(2) Willis Avenue Site - The Willis Avenue Site contains benzene, toluene, xylene, naphthalene and chloro benzene and some other lower concentrations of contaminants. These pollutant materials are suspected to be migrating into the groundwater system and eventually entering into Onondaga Lake.

(3) Clark Property - The Clark Property is the site of a former concrete and asphalt operation located just south of Onondaga Lake. The site was a major oil storage facility but it is now an inactive hazardous waste site, which contains the presence of solvent contamination.

(4) Quanta Site - The Quata site is a former oil reprocessing plant which has been closed since 1980. The contaminants which are stored in tanks are waste oils, sulfuric acid and PCB's.

(5) Maestri Site - The Maestri site was used by Stauffer Chemical for the disposal of 70-90 waste disposal drums. The groundwater is contaminated with xylene.

(6) McKesson Site - The McKesson site contains numerous storage tanks that were used for the storage of bulk petroleum products and waste solvents. Although some remedial cleanup has been completed, some remaining contaminated soil and groundwater is present at the site.

(7) Allied Tar Beds - The Allied Tar Bed site, 22 acres, was used between 1917-1920 for the disposal of tar-like waste from its former benzene related operations. The wastes have contaminated the groundwater with benzene, toluene, and naphthalene and are suspected to be migrating toward Onondaga Lake and toward tributary 5A.

(8) Ley Creek Land Fill - Upstream from the mouth of Ley Creek along the banks is located the disposal site for dredged sediment from Ley Creek.

# LOCATION MAP
# OF
# ALLIED DISPOSAL SITES
## ONONDAGA LAKE, NEW YORK

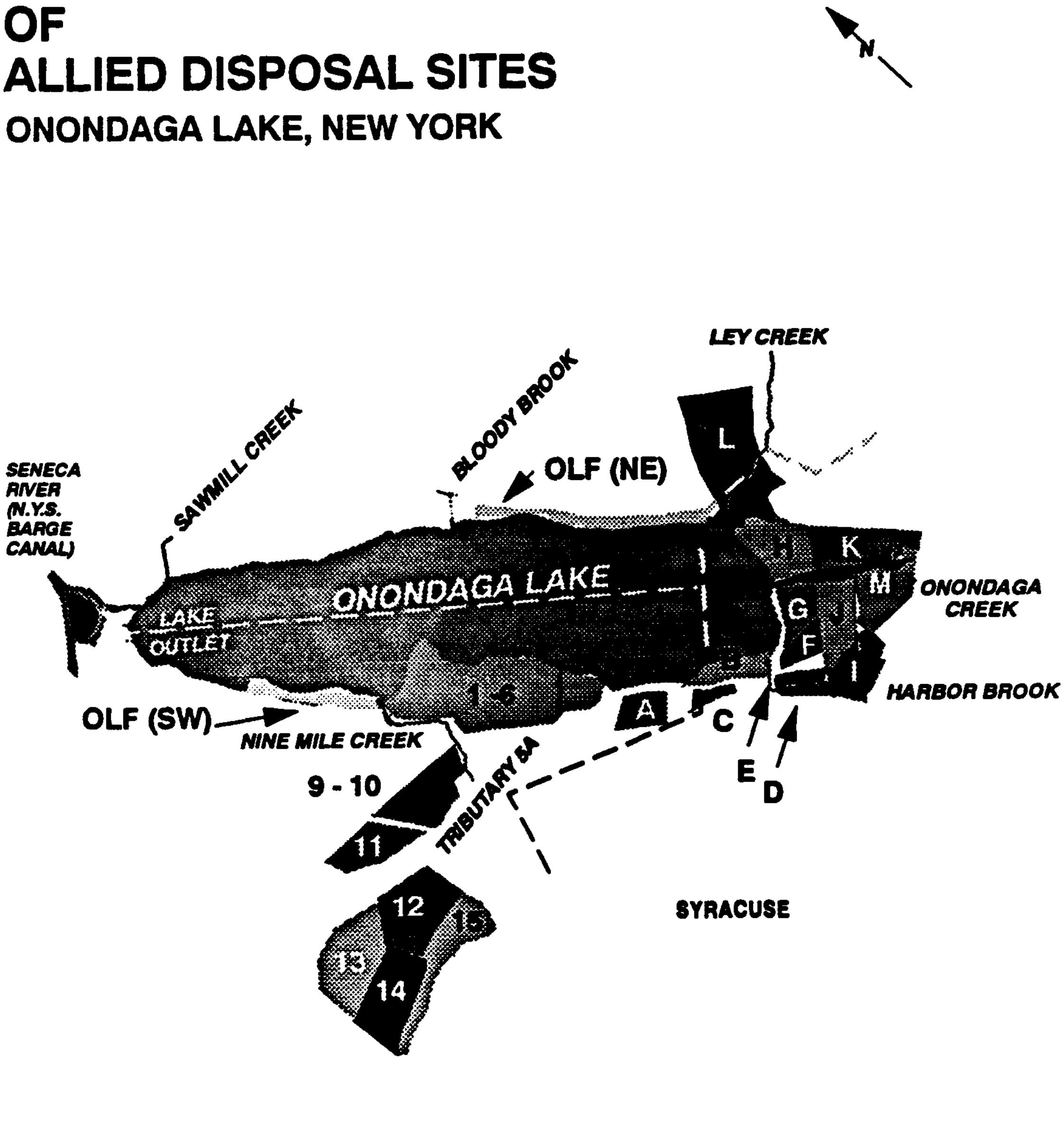



**Figure 10** - Allied Chemical Waste Disposal Sites, Onondaga Lake

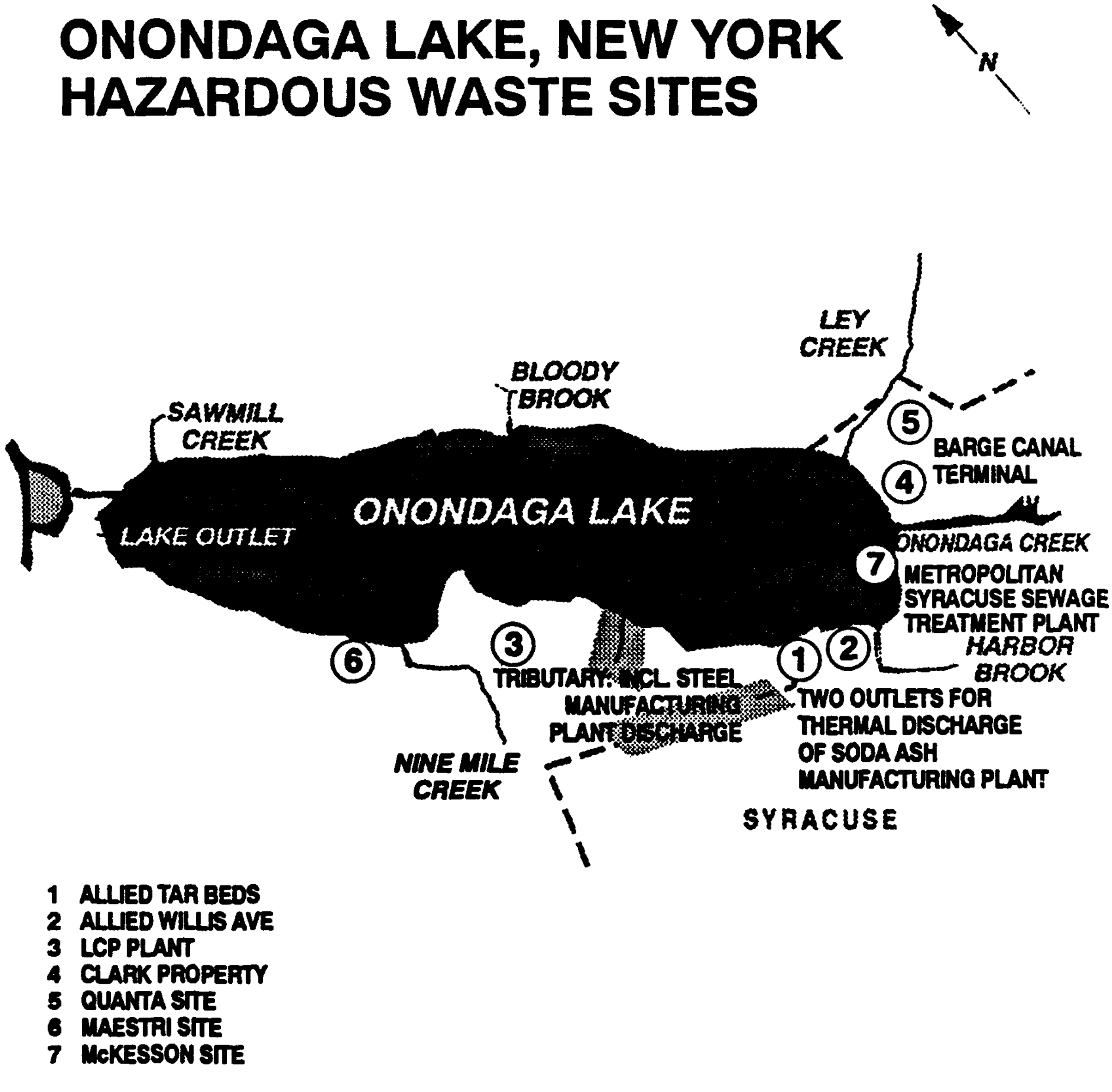



**Figure 11** - Hazardous Waste Disposal Sites, Onondaga Lake

The sediment chemical quality of this material is unknown.

(9) Linden Chemical and Plastics (LCP) Site - The LCP (Hanlin Group) manufacturing facility was formerly owned by Allied Chemical. The primary contaminant which has been identified at this site is mercury and has infiltrated in the soil and groundwater.

(10) Oil City Area - Oil City is a triangular shaped area located at the southeastern end of the lake between routes 81 and 690. Located in this area of Syracuse are nine major oil terminals. Over the years various spills or leaks have occurred and created plumes of dissolved product and pure product. Past efforts to recover these plumes were not successful because of the closeness of the facilities and the complexities of the facilities and groundwater patterns. Future plans propose moving the tank farms from the Syracuse area and converting the land use to residential and commercial. In the fall of 1990, a multi-million dollar shopping mall, Carousel Center, was completed on the eastern shore of Onondaga Lake. This mall was designed to be the centerpiece for future development. Former warehouses in the Franklin Square area of Oil City are being converted into condominiums and commercial offices. Future Oil City plans call for development of a recreational harbor and marina area surrounded by new residential and light commercial development. The success of this future proposed development will depend on the ability to clean up this site.

(11) NYS Barge Canal Terminal - The New York State Barge Canal Terminal and maintenance area is located in the lower reach of Onondaga Creek near the southeastern end of Onondaga Lake. The NYS Department of Transportation (NYSDOT) owns and maintains this area. The area has been a repository for dredged spoils. The sediment chemical quality has not been determined for sediments in this channel.

3.2.3.15 Non-Point Sources - The Water Quality Act of 1987 focused increased attention and priority on the development and implementation of non-point source control programs. The New York Department of Environmental Conservation (NYSDEC) has identified categories of non-point sources that are significant problems. The NYSDEC, in conjunction with the New York State Soil and Water Conservation District, has worked to identify sources of non-point pollution.

A major source of sediment and dissolved salts has been identified in the Onondaga Creek watershed in the Tully Valley. The source has been isolated to an area where sediment is introduced to the surface water through the groundwater. This is referred to as the "Mud Boil" phenomenon. This phenomenon contributes significant amounts of sediment to Onondaga Creek, and in turn contributes to the cloudiness of Onondaga Lake. This increased sedimentation downstream of the "Mud Boil" area has adversely impacted upon the Onondaga Creek fishery.

The "Mud Boils" are surface features consisting of cone shaped structures which

range in diameter from less than 1 meter to 5 meters and are usually less than .6 meter in height, although some are as high as 1 meter. These features may be subsidence related and are comprised of sand, silt, and clay brought to the surface by artesian pressure. Based upon NYSDEC estimates, the mud boil effluent contains 25 to 75 percent sediment. The NYSDEC and the New York State Attorney General's Office has been analyzing the process that causes the "Mud Boils" and the relationship to subsidence.

The Onondaga Lake Management Conference is coordinating efforts with the U.S. Soil Conservation Service to design and construct a diversion channel to divert upstream surface water flows away from the mud boil area. This proposed plan is similar to the proposed mud boil alternative addressed later in this report.

3.2.3.16 Sediment Sources - The in-place lake sediments provide a source of pollutants by recycling and retaining the various contaminants within the Lake's system. The primary parameters that are associated with the sediments include phosphorus, nitrogen, mercury, PCB's, heavy metals, calcium carbonate, and sulfides.

Internal phosphorus has been identified as impacting the water column phosphorus concentrations. The release rate from the sediments is governed by the rate of phosphorus deposition and the oxygen level of the overlying water. As external loads of phosphorus are reduced, the release rate can be expected to decrease.

PCB's, mercury and other heavy metals (Cd, Cu, Cr, Ni, Zn and Fe) are present in the sediments and have been taken up in the food chain. Testing of fish flesh has found varying concentrations of these parameters, with mercury being the most serious health threat.

Calcium carbonate (Calcite) is a problem along the Lake's littoral zone. It precipitates out and will encrust particulate matter to form oncolites. The oncolites form a light gravel-like material that shifts continually with the wave action in the lake. This prohibits aquatic vegetation from rooting and developing in the shallow shoreline areas. The presence of the calcium carbonate also adversely impacts upon the transparency of the water.

Sulfides are produced in the sediments as the organic material dies and decomposes.

### 3.2.4 Pollutant and Nutrient Loading

3.2.4.1 Phosphorus has long been recognized as the most critical nutrient controlling phytoplankton growth in most lakes. Phosphorus inputs are currently high enough to support extensive levels of algal production. Phosphorus sources have been

classified as either external or internal. External sources deliver new phosphorus to the Lake from point and non-point sources. Internal loads constitute the biogeochemical cycling of phosphorus within the lake. High phosphorus loading to Onondaga Lake from the sediments is partially attributed to the high concentrations of calcium byproducts concentrated in the lake. The response of the lake to changes in phosphorus loading is very rapid as shown by the historical data because the lake flushes between 2.6 to 5.2 times per year.

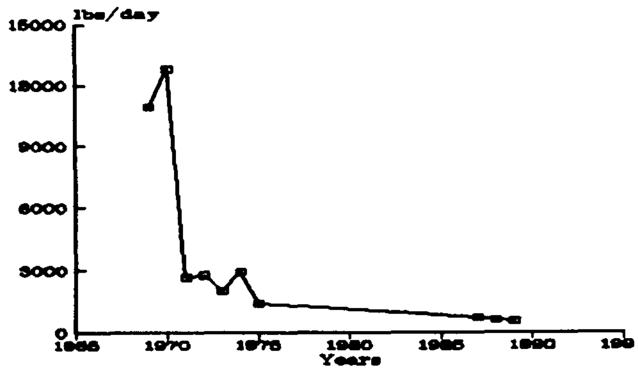


Figure 12 - Historical Phosphorus Loads to Onondaga Lake

Over the past twenty years phosphorus loads have dramatically reduced, see Figure 12. This improvement is primarily due to a ban on detergents using phosphorus in 1970 and to staged upgrades at the Metro Sewage Treatment Plant.

3.2.4.2 Nitrogen is found in the form of ammonia, nitrate, and nitrite. Ammonia comprises the largest component (80 %). The primary sources of total ammonia are inputs from the watershed and the decomposition of organic matter in the lake. As an example of external loading, Metro was responsible for 89.4 percent of the ammonia as recorded during sampling in 1988 (Source: Onondaga County). The decomposition of organic material results in elevated levels of ammonia in the hypolimnion during stratification.

The 1988 monitoring program performed by Onondaga County Department of Drainage and Sanitation showed that the concentrations of ammonia in the lake were above the NYSDEC chronic toxicity standards on more than 80 percent of the sampling days in the epilimnion and the hypolimnion. These violations can persist from the spring through the fall.

3.2.4.3 Ionic Salts - The loading of Ionic salts (calcium, sodium, and chloride) to Onondaga Lake have been reduced significantly in recent years primarily due to the closing of Allied in 1986. The results of the 1989 monitoring data shows that Nine Mile Creek continues to be the largest contributor of the ionic salts to the lake. Onondaga Creek is the second highest contributor, with the Metropolitan Sewage Treatment Plant being the third largest.

3.2.4.4 Heavy Metals - The loading of heavy metals has been reduced in recent years due to stricter regulations and more advanced technology. Loadings of

iron, chromium, and copper to Onondaga Lake was significantly reduced in 1974 when Crucible Steel built a water treatment and reuse system. Loadings of mercury to Onondaga Lake were also significantly reduced upon the closure of Linden Chemical and Plastics (mercury cell process) in 1988.

The 1989 Onondaga County monitoring data shows that Metro contributes the greatest quantities of lead, copper, chromium, and cadmium. Nine Mile Creek is the second highest contributor, and Onondaga Creek is third. For loadings of mercury to the Lake, Nine Mile Creek is the largest contributor followed by Metro and Onondaga Creek.

3.2.4.5 Bacteria - The concentration of fecal coliform bacteria in the waters of Onondaga Lake is measured by the New York State Department of Health to help determine whether the water can be safely used for contact recreation. The current standard specifies that the logarithmic mean of five fecal coliform samples collected on successive days not exceed 200 colonies per 100 ml of water.

The monitoring program performed by Onondaga County has collected biweekly data since 1977. These data are not representative of conditions during periods of high runoff, and therefore, are not sufficient to determine compliance with established standards. The results of the County's 1988 monitoring show that Onondaga Creek contributes the highest percentage of fecal coliform, with Nine Mile Creek second and Ley Creek third. Ley Creek is the greatest contributor of fecal strep, with Onondaga Creek second and Metro third.

3.2.4.6 Biological Oxygen Demand - The biological oxygen demand is another parameter monitored by Onondaga County. The concentrations of BOD were found to peak during periods of zero hypolimnetic - dissolved oxygen, caused by the die off of a preceding algal bloom. As the algal bloom terminates, dead cells and residual constituents settle from the surface to the hypolimnion and are subject to bacterial decomposition, resulting in the observed BOD peaks and depressed dissolved oxygen. The County's 1989 data show that Metro contributes the most BOD (53.0%), Ley Creek contributes 17.7%, Onondaga Creek contributes 15.9%, and Nine Mile Creek contributes 12.2%. The 1988 monitoring data showed a concentration of 17.9 mg/liter with a load of 11,700 lb/day; although the SPDES permit level limits the concentration to 15 mg/liter and the loading to 10,100 lb/day.

3.2.4.7 Sediment - The sediment load into the lake is contributed from watershed tributaries and the Metro plant. Onondaga Creek has the largest watershed, and it contributes the highest sediment load. However, the contribution of sediment from the "Mud Boil" area in the Tully Valley significantly increases the sediment load. New York State is currently investigating the "Mud Boil"

phenomenon, and a more accurate determination of sediment quantities will be made.

## 3.3 Planning Constraints

A Senate document authorized the Corps of Engineers to determine what improvements in the interest of water quality and environmental enhancement are advisable for Onondaga Lake. Traditionally, water quality remediation has not been a Corps mission. The Army's position is summarized in the shaded area.

***The Department of the Army's position regarding the study of Onondaga Lake was included in the Army's Letter Report on Congressional Bill S. 2183, which was provided to Congress on March 20, 1990. It has been the Administration's position that cleanup of Onondaga Lake is not an appropriate function of the Federal Water Resources Development Program. There are already a number of Federal Programs designed to address waste water cleanup, and cleanup of Onondaga Lake should be pursued under these programs, not under a special program authorization.***

*Department of the Army Position*

The work during the study was constrained by several factors:

(1) No agreed upon method to measure water quality benefits;

(2) No means to evaluate, other than subjective, the impact the alternatives would have on the lake; New York State is developing models of the lake which will predict how the lake will respond to loading changes.

(3) The NYS litigation against Allied; and

(4) The lack of agreement on water quality standards, i.e. ammonia.

Therefore, this is basically a technical report containing a matrix of alternatives with preliminary cost estimates. The report reviews the measures available to determine if sufficient information exists to solve the water quality problems that exist in Onondaga Lake. A qualitative evaluation of all alternatives is contained in this report.

## 3.4 Planning Objectives

3.4.1 National Objective - Current Federal policy, as developed by the President's Water Resources Council, requires that alternative water and resource plans be formulated in accordance with the national objective of National Economic Development (NED). National Economic Development is achieved by increasing the

value of the nation's output of goods and services and improving economic efficiency consistent with protecting the nation's environment. Traditionally, the National Economic Development objective will be achieved through construction of a project or projects where the benefits are greater than costs.

3.4.2 Specific Planning Objectives - Specific planning objectives are the National, State, and local water and related land resource management needs specific to a study area that can be addressed to enhance National Economic Development. The specific objectives of this Reconnaissance Phase study are:

3.4.2.1 Enhance National Economic Development by recommending measures to improve the quality of Onondaga Lake;

3.4.2.2 - Produce a lake acceptable for contact recreation (swimming) by:
(1) Increasing transparencies to values greater than New York State standards, and
(2) Decreasing total coliform and fecal coliform to values below New York State standards;
(3) Reducing Phosphorus concentrations.

3.4.2.3 - Produce an acceptable cold water fishery by:
(1) Reducing average total ammonia concentration to a level below 0.27 milligrams per liter as defined by the Upstate Freshwater Institute.
(2) Increasing hypolimnion dissolved oxygen (DO) to a minimum of 6.0 milligrams per liter at any point in the bottom waters. Then maintain a value close to saturation during stratification.
(3) Decreasing Mercury (Hg) concentrations in the fish to a level that would allow consumption of the fish;
(4) Reducing and maintaining Nitrite - Nitrogen concentrations below the toxicity level for aquatic life (fish); and
(5) Removing the sediment load and turbidity of Onondaga Lake through remedial action on the "Mud Boils" in the Onondaga Creek watershed;

3.4.2.4 Produce an Acceptable Drinking Water Supply with Minimal Treatment by:
(1) Reducing and maintaining Total Ammonia concentration to a level below the drinking water standards;
(2) Maintaining Nitrite and Nitrate - Nitrogen concentrations at levels below the New York State drinking water standards; and
(3) Reducing chlorides to a level below 250 milligrams per liter;
(4) Reducing toxic organic compounds.

3.4.2.5 Provide an Environmental Enhancement to the natural

environment.

### 3.5 Without Project Conditions

As a base condition, the most "probable future" is the scenario and conditions that would exist if no action were taken. This is what is referred to as the "Without Project Condition". It does not mean that no actions would be taken, but that any proposed actions are compared to the "Without Condition" to determine their merits.

The State of New York has taken or is considering legal action against the major companies or entities that have or are continuing to pollute Onondaga Lake. New York State, using litigation and consent orders, will continue to require the polluters to conduct studies, sampling, or modeling to define the pollution source, and formulate cleanup actions; and to contribute to the clean up of the Lake. In addition, there has been discernable progress to cleanup the Lake during the past two decades. Phosphorus loadings have decreased as the result of improvements to the Metro plant. Mercury and ionic salt loadings have decreased as a result of chemical plant closures. However, it is unlikely that the water quality objectives for the lake will be met without supplemental efforts.

# 4 - FORMULATION OF MEASURES

### 4.1 Plan Formulation Rationale

The objective of plan formulation is to combine measures into plans that solve the water quality problems of Onondaga Lake. Extensive technical investigations have been undertaken by the State, County, and City in the interest of improving the water quality of Onondaga Lake. This report attempts to assess these efforts to determine whether supplemental actions are needed to solve the water quality problems of Onondaga lake. The plan formulation process attempts to develop the most efficient set of alternative measures that solve the problems and still be viable for investment. One endeavor during this study has been to develop economic methodologies to evaluate the outputs of the plans. Water quality improvements have traditionally been made based on environmental need, the health and welfare of the constituents, and to varying degrees the perceived social acceptability. However, it is also important to do some quantitative analysis to assure the plans formulated are the most efficient solution. This economic analysis was not accomplished, due to the planning constraints of this technical report.

### 4.2 Formulation and Evaluation Criteria

In water resources planning, plans must be formulated to meet the needs of the area with due regard to benefits and costs, both tangible and intangible, and the

> ***The planning framework is established in the Water Resources Council's "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies", which requires the systematic preparation and evaluation of alternative solutions to problems. The process also requires that the impacts of a proposed action be measured and the results displayed or accounted for in terms of contributions to four accounts: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The formulation process is conducted without bias to structural or nonstructural measures.***

*Water Resources Council's Planning Framework*

effects on the environment and social well-being of the community. As was discussed above, water quality investments have been made based on more than just economic considerations. Identifying the most efficient solutions with the participation of local agencies is critical to formulating a solution that is both efficient and responsive to the public need.

Within the structure of the overall planning framework, other more specific criteria must be established relative to: general policies, technical engineering, economic principles, social and environmental values, and local conditions. These criteria, noted as "Technical", "Economic", and "Socioeconomic and Environmental" are as follows:

4.2.1 Technical Criteria - Remedial alternatives for this study are limited to Onondaga Lake, its contributing tributaries, and the interaction with the New York State Barge Canal System (Seneca River). Upland alternatives to contain pollutant sources will not be addressed in this report, other than to identify the pollutant sources. The only exception is to investigate a general plan of action for the sediment loads from the Tully Valley "Mud Boil" area which is in the Onondaga Creek watershed. Specific alternatives to cleanup "point sources" at waste disposal sites or landfill sites are considered to be beyond the scope of this study and are not included in this report. However, they may be identified for in-depth analysis in future studies, if they are determined to be a significant problem.

4.2.2 Economic Criteria - No economic benefits will be provided in this technical report as decided during a meeting involving Headquarters, North Central Division and Buffalo District on 25 June 1990. It was decided that, the methods and procedures for deriving economic benefits would be identified during the reconnaissance phase and would be applied during a later phase of study, if undertaken. Later the reconnaissance investigation was replaced with a strictly technical investigation. This technical report contains a matrix of alternatives with associated costs. A qualitative analysis of all alternatives is presented in Section 5.

4.2.3 Socioeconomic and Environmental Criteria - All significant adverse and beneficial economic, social, and environmental effects of planned developments will be considered and evaluated during plan formulation. The criteria for socioeconomic and environmental considerations in water resources planning are prescribed by the National Environmental Policy Act of 1969 (PL 91-190) and Section 122 of the River and Harbor Act of 1970, (PL 91-611).

4.2.4 Mitigation Factors - The Environmental Assessment contained in Technical Annexes assesses each of the alternatives and their impact upon the environment. Because the intent of this study is to improve water quality and provide environmental enhancements, it is unlikely that there will be a need to mitigate any of the plans.

4.2.5 Other Criteria - Formal assurances of local cooperation must be furnished by a non-Federal sponsor capable of fulfilling all items of local cooperation. Historically, Corps of Engineers projects in New York State have been sponsored by the New York State Department of Environmental Conservation or the New York Office of Parks, Recreation and Historic Preservation. Since this is a technical report this criteria for cost sharing is not required.

### 4.3 Management Assistance

The Onondaga Lake Management Conference (OLMC) is a multi-level (Federal, State, County, and City) not-for-profit body responsible for the management of efforts to clean up Onondaga Lake. The OLMC is funded by Congress to prepare a "State of the Lake" report followed by preparation of a Management Plan to coordinate the efforts of all parties involved in the cleanup of Onondaga Lake. A more detailed description of the OLMC is contained in Section 1.8 of this report. The Corps of Engineers, who is a member of the Management Conference, is preparing this report to summarize all the study efforts to date, and proposes actions to assist the Management Conference in the preparation of their Management Plan. The Corps will also continue to participate as a member of the Management Conference and subcommittees; the Technical Review Committee and various working groups.

### 4.4 Plan Development and Description

Within the prescribed planning framework and established criteria, possible solutions were identified and will be evaluated in a two-stage iterative process to address the needs of the study area and the overall planning objectives. Each stage includes the four functional planning tasks of problem identification, formulation of alternatives, impact assessment, and evaluation. Emphasis shifts from the identification to evaluation task as this iterative process is refined in the next phase of the study process.

This document reports the results of this evaluation. The level of study performed is consistent with the objective of evaluating a broad range of possible solutions and identifying a general plan (or matrix of plans) for satisfying the water resource needs of the Onondaga Lake study area.

Section 5 of this report will combine the measures to produce alternative plans that will address single goals or multiple goals. The single aspect measures will be merged in various combinations to form alternative plans to address specific study objectives (i.e. improve water quality to the point where it can be used for swimming, fishing, and drinking, and provide environmental enhancements). A matrix of

measures resulting is presented in the next section of this report.

### 4.5 Formulated Measures

The formulated single aspect measures are limited action plans, that do not by themselves address all the requirements of the water quality goals. They only will have beneficial impacts on selected pollutant parameters. Therefore, by combining the alternative measures to address a wider range of parameters, selected goals can be met. Table VIII lists all of the water quality improvement measures evaluated during the formulation of this technical report.

**Table VIII** - Single Aspect Measures, Onondaga Lake

Single Aspect Measures

- Dredging of Onondaga Lake
- Confined Disposal Facilities
- Solidification of Contaminated Sediments
- Capping of Contaminated Sediments

- In-lake Treatment
  - Aeration of the Hypolimnion
  - Chemical Treatment

- Non-point Sources
  - Mud Boils on Onondaga Creek
  - Wastebeds

- Natural Development - Environmental Enhancement

- Metro Sewage Treatment Plant
  - Phosphorus Removal
  - Ammonia Removal
  - Nitrogen Removal
  - Effluent Discharge Alternative

- Combined Sewer Overflow (CSO) Treatment and or Diversion
  - Regional CSO Collection and Treatment Facilities
    - Separation of Combined Sewer Systems
    - Storage Options Alternatives
  - Centralized CSO Transmission and Treatment Facilities
    - High Rate Treatment Facilities
    - In-water Containment Structures (Flow Balance Method)
    - In-line Tunnel Storage

These measures address water quality improvements and environmental enhancements that fall into four broad categories: removal of polluted lake sediment,

capping of polluted lake sediment, in-lake treatment, and ,if significant, management of non-point sources of pollution. Preliminary cost estimates were developed for each of the measures and are summarized in Table X at the end of this section. Each of these measures are discussed in more detail in the following paragraphs.

4.5.1 Dredging of Onondaga Lake - As a result of industrial activities during the past one hundred years, vast amounts of pollutant discharges have settled in the form of sediments. The bulk of these discharges are comprised of mercury, and alkali-wastes (including calcium chloride, sodium chloride, calcium sulfate, and calcium carbonate). The alkali-wastes are considered to be non-toxic, although they do impact upon the chemistry and the environment of the lake. They can be as thick as 6 feet. With about 4.6 square miles of lake bottom, dredging for the purpose of removing the alkali wastes may be impractical due to the large quantity of material. Mercury also has a wide distribution and high concentration within the sediments at all depths of the lake. The greatest concentrations of mercury are in the deepest portions of the lake. Through the identification of "hot spots", the dredging can be reduced.

The volume of excavation required to remove sediment containing mercury concentrations greater than or equal to 1.0 parts per million (ppm) has been estimated to be 6,500,000 cubic yards covering an area of 2,610 acres. The volume of excavation to remove sediment containing mercury concentrations greater than or equal to 5.0 ppm has been estimated to be 3,000,000 cubic yards covering an area of 2,140 acres. The volume of excavation to remove sediment containing mercury concentrations greater than or equal to 10.0 ppm has been estimated to be 2,000,000 cubic yards covering an area of 1,880 acres. Figure 13, Figure 14, and Figure 15 show the approximate areas that would need to be dredged to remove sediments containing mercury at 1.0 ppm, 5.0 ppm, and 10.0 ppm or greater; respectively.

The concern regarding mercury is that it is showing up in the fish. The investigations to date have not established whether it is moving from the sediments up the food chain into the fish, or if it is getting into the fish some other way. The extent of the dredging necessary to reduce the mercury concentrations in fish is currently not known. Dredging and Capping the polluted sediments with clean material would also reduce the release of nutrients from these sediments, their sediment oxygen demand, and the uptake of other metals and organic compounds by aquatic organisms.

Dredging costs associated with removal of polluted lake sediment is a function of cubic yards removed and type of equipment used. A range of dredging equipment was analyzed to determine the most appropriate and cost effective means of removing this polluted lake sediment. This included the characteristics and quantity of sediments, dredging depth, level of contamination, re-suspension of contaminated sediments, limitations of the Oswego and Erie Canal systems, and disposal of the

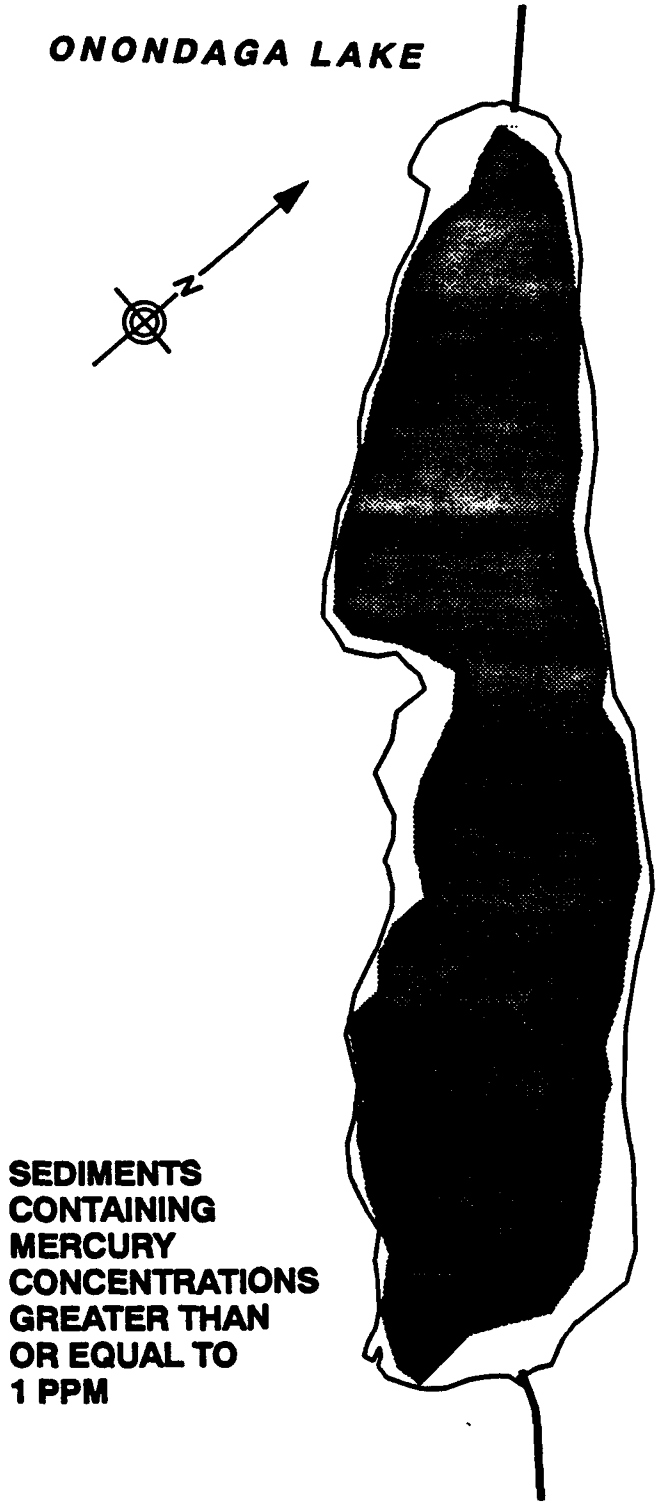



**Figure 13** - Area of sediments containing mercury concentrations greater than or equal to 1.0 ppm, Onondaga Lake

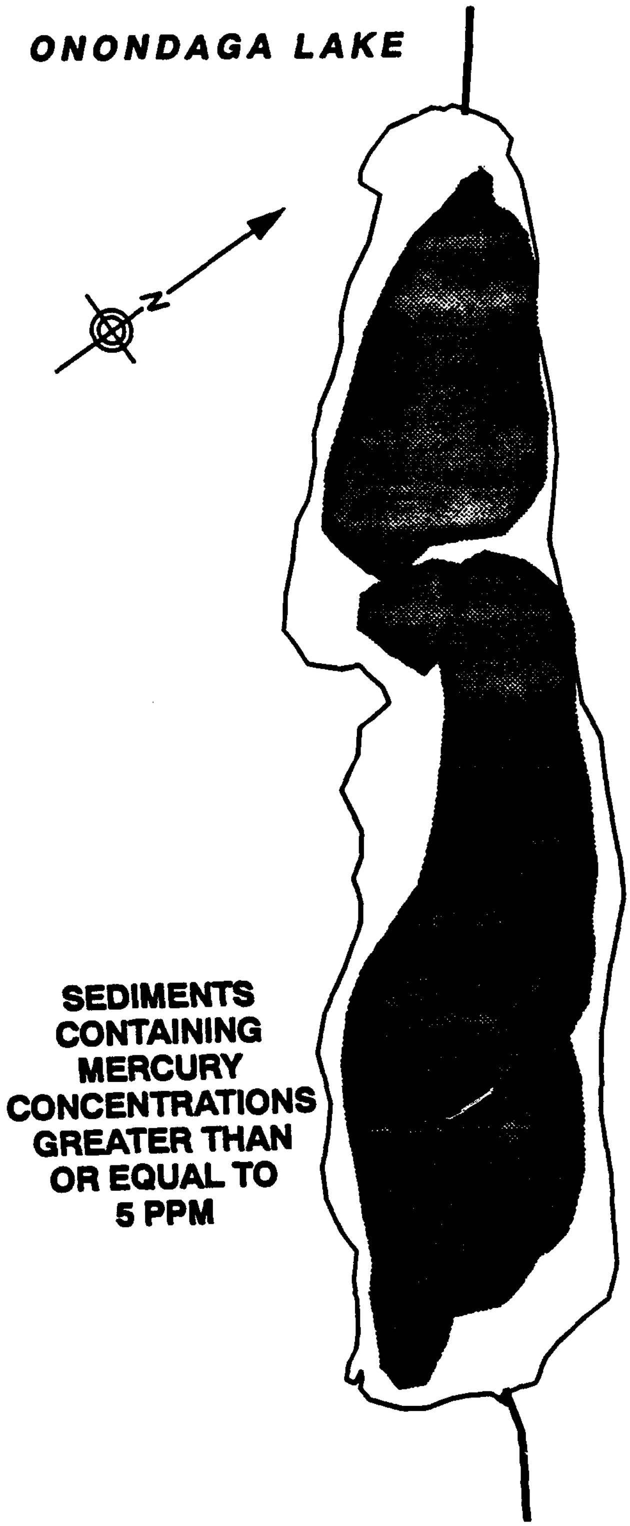



**Figure 14** - Area of sediments containing mercury concentrations greater than or equal to 5.0 ppm, Onondaga Lake

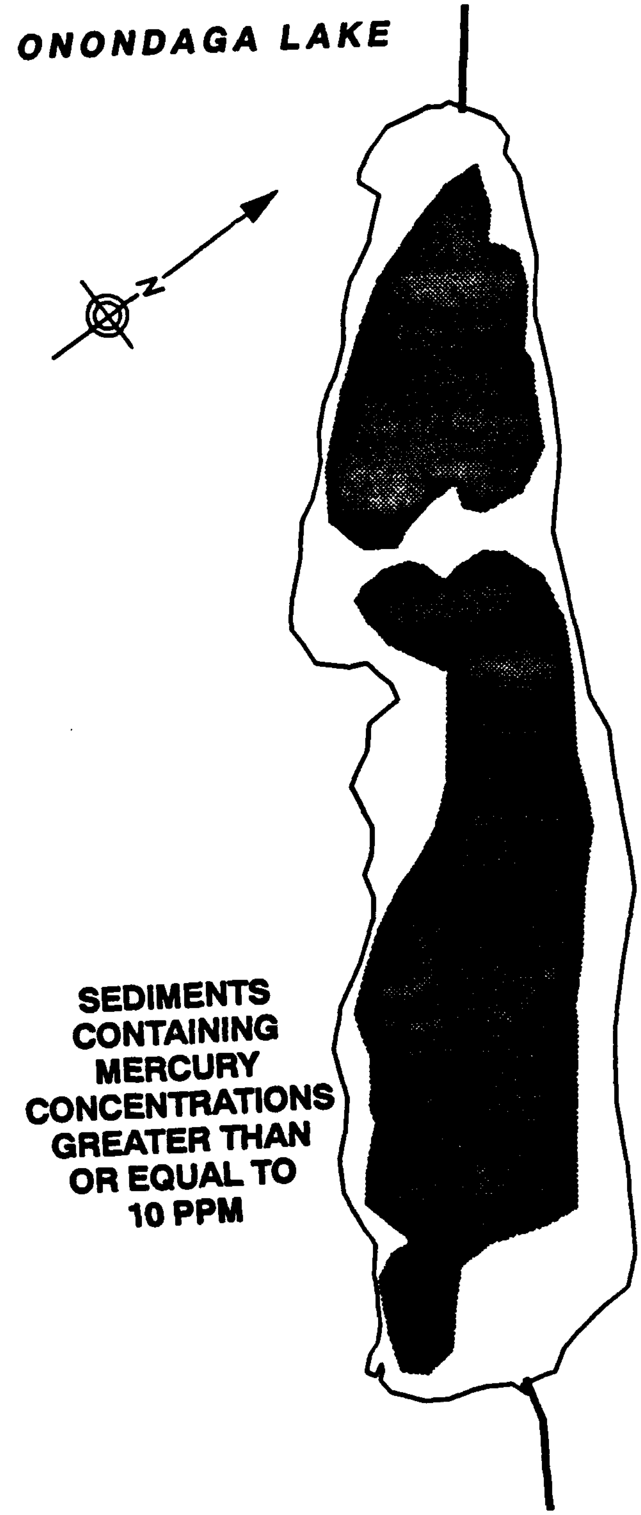



**Figure 15** - Area of sediments containing mercury concentrations greater than or equal to 10.0 ppm, Onondaga Lake

material. A detailed analysis of these conditions and limitations is contained within the Water Quality Technical Annex A, Section 5.

Based on preliminary investigations for this level of report, the enclosed clamshell dredge, hydraulic pipeline cutterhead dredge, PNEUMA pump pneumatic dredge, match-box and waterless dredges should be considered for removal of contaminated sediments from Onondaga Lake. It may be necessary to use two varying types of dredges for Onondaga Lake due to the large quantity of sediments, depth of contaminated sediments and clearance restrictions on the New York State Barge Canal system. For cost estimating purposes in this report, it was assumed that a hydraulic dredge would be assembled on site to accomplish the proposed dredging. Planning, engineering and design, and construction management are included in the cost estimates as well as mobilization and demobilization and a contingency. All costs are based on June 1990 price levels. As summarized in Table X, the cost of dredging 6,500,000 cubic yards of sediments with mercury concentrations of 1.0 part per million (ppm) or greater is $61,700,000. The cost for dredging 3,000,000 cubic yards of sediments with mercury concentrations of 5.0 ppm or greater is $28,500,000. The cost for dredging 2,000,000 cubic yards of sediments with mercury concentrations of 10.0 ppm or greater is $ 19,100,000. These costs do not include the cost of the confined disposal facilities.

<u>4.5.2 Confined Disposal Facilities</u> - Of the six separate confined disposal facility (CDF) configurations formulated, two were eliminated because they did not have sufficient capacity. The CDF's are discussed in greater detail in the Water Quality Annex. However, since the major objective was to assign a cost to the disposal, and not optimize their location, the figures showing their proposed sites remain in the Water Quality Technical Annex. All the proposed locations of these CDF sites are in the lake along the south and southwest shorelines. The CDF's were sized to accommodate the volume of excavation required to remove sediment containing the following mercury concentrations:

| | |
|---|---|
| Greater than or equal to 1.0 ppm | = 6,500,000 cubic yards |
| Greater than or equal to 5.0 ppm | = 3,000,000 cubic yards |
| Greater than or equal to 10.0 ppm | = 2,000,000 cubic yards |

Preliminary cost estimates based on June 1990 price levels were made of the four confined disposal facilities. These estimates anticipated clay borrow would be available within five miles of the construction site. Stone products required for construction will be obtained from quarries in the region. Planning, engineering and design, and construction management costs are also included in the estimates, as well as a contingency on the construction costs. The cost of constructing Design 1, to hold 6,500,000 cubic yards of sediment in up to 22 feet of water, has been estimated at $63,500,000. The cost of constructing Design 2, to hold 6,500,000 cubic yards of

sediment in up to 6 feet of water, has been estimated at $50,700,000. The cost of constructing Design 3 CDF, to hold 3,000,000 cubic yards of sediment has been estimated at $20,900,000. The cost of constructing Design 4 CDF, to hold 2,000,000 cubic yards of sediment has been estimated at $17,500,000. These cost estimates are preliminary and are subject to change based on the final CDF design, including its location, size, and cross section as well as the availability of construction materials and other factors affecting cost.

4.5.3 Solidification of Contaminated Sediments - The dredged sediments may be solidified or stabilized in the confined disposal facility by mixing the sediments with a setting agent. The purpose of the solidification is to stabilize contaminated sediments or chemically immobilize the contaminants or both.

The term solidification describes the elimination of free water from a semi-solid by addition of a settling agent such as portland cement, lime, fly-ash, kiln dust, or slag. The bulk of solidification technologies currently under evaluation require the removal, and in some cases, the de-watering of the contaminated sediments. Any alternative exploring the use of solidification at Onondaga Lake will require laboratory testing of setting agents and their interactions with the contaminated sediments. Field testing examining mixing efficiency and long term stability of the treated material should also be conducted.

Preliminary cost estimates were developed for the solidification/stabilization process. Very little actual cost data are available for this procedure because it has not been used on sediment. Therefore, a range of estimates was prepared for the solidification at a staging or disposal area. These estimates are based on unit costs of $50 -$80 per cubic yard. These costs per cubic yard include costs for planning, engineering and design, and construction management. The costs did not include the cost of dredging or final disposal. This resulted in a cost of solidification that ranges from $160,000,000 to $520,000,000 depending on the concentration of mercury removed. Table X shows these costs for the upper limit of $80 per cubic yard of sediment treated. More details on this particular measure can be found in Section 5 of Annex A.

4.5.4 Capping of Contaminated Sediments - An alternative to dredging the contaminated sediments in Onondaga Lake is aquatic burial. This option involves the capping of contaminated sediments with cleaner borrow material. Capping would reduce mercury contamination as well as reduce releases of nutrients from the sediments, sediment oxygen demand, and uptake of other metals and organic compounds by aquatic organisms. The capping concept may involve contained aquatic disposal(CAD). This technique necessitates placing contaminated sediments in a small area such as an existing depression, in an excavated disposal cell, or in submerged dikes or berms. This disposal area is then covered (capped) with clean

borrow material. A CAD site is an engineered structure whose successful performance depends on proper design and construction.

The vast majority of the Onondaga Lake bottom is covered with mercury contaminated sediments. Additionally, the excavation of a "disposal cell" in Onondaga Lake would require the dredging and temporary storage of contaminated mercury sediment.

In order to avoid having to store contaminated sediment and avoid the adverse impacts of dredging, capping of polluted material "in place" was considered. Two capping procedures were considered: using a submerged diffuser and bottom dumping. The submerged diffuser method would result in less suspension of contaminated sediments than bottom dumping, would offer greater control over placement of the capping material, and provide a more uniform cover than placement by mechanical means. The success of the capping procedure is dependent upon the nature and thickness of the capping material placed over the contaminated sediments. The cap must also be of sufficient thickness to prevent both chemical diffusion and mechanical breaching (wave scour and burrowing of aquatic organisms) of the cover.

Several preliminary cost estimates were made for capping of contaminated sediments in Onondaga Lake. The number of acres needing coverage depends on mercury levels, as shown in the shaded area.

| *Mercury Concentration* | *Bottom Area (Acres)* |
|---|---|
| *< 1 ppm* | *2,610* |
| *< 5 ppm* | *2,140* |
| *< 10 ppm* | *1,880* |

*Bottom Surface Area of Various Mercury Concentrations*

Costs of four different depths of coverage were estimated: 0.5 feet, 1.0 feet, 2.0 feet and 3.0 feet (reference Table IX). It was estimated that 75 percent of the polluted acres are located in water depths exceeding 25 feet. These areas would be covered with sand only. Contaminated sediments located in less than 15 feet of water ( about 10 percent) would require a three-layer cap consisting of 3 feet of sand covered by 2 feet of gravel covered by 2 feet of armor stone. The armor stone will protect the cap from currents and wave action. Contaminated sediments in water depths ranging from 15 to 25 feet (about 15 percent) would be covered with just a two-layer cap (3 feet of sand and 2 feet of gravel).

There does not seem to be a readily available source of clean cover material in the lake. It is anticipated that sand borrow will be available within 10 miles while the gravel and armor stone will be obtained from quarries in the area. Estimates for the various capping options are shown in Table IX. These cost estimates are based on

**Table IX** - Construction Costs For Capping Measures. (June 1990 price level)

| | |
|---|---|
| **A. Cover All Sediments That Have 1 PPM or Greater of Mercury (2,610 acres of lake bottom)** | |
| 1. 0.5 feet of sand plus shallow water cap | $ 198,000,000 |
| 2. 1.0 feet of sand plus shallow water cap | $ 226,000,000 |
| 3. 2.0 feet of sand plus shallow water cap | $ 284,000,000 |
| 4. 3.0 feet of sand plus shallow water cap | $ 341,000,000 |
| **B. Cover All Sediments That Have 5 PPM or Greater of Mercury (2,140 acres of lake bottom)** | |
| 1. 0.5 feet of sand plus shallow water cap | $ 162,000,000 |
| 2. 1.0 feet of sand plus shallow water cap | $ 186,000,000 |
| 3. 2.0 feet of sand plus shallow water cap | $ 233,000,000 |
| 4. 3.0 feet of sand plus shallow water cap | $ 280,000,000 |
| **C. Cover All Sediments That Have 10 PPM or Greater of Mercury (1,880 acres of lake bottom)** | |
| 1. 0.5 feet of sand plus shallow water cap | $ 143,000,000 |
| 2. 1.0 feet of sand plus shallow water cap | $ 163,000,000 |
| 3. 2.0 feet of sand plus shallow water cap | $ 205,000,000 |
| 4. 3.0 feet of sand plus shallow water cap | $ 246,000,000 |

June 1990 price levels, and include planning, engineering and design, and construction costs. The costs for the various capping options range from a low of $143,000,000 to cover all sediment with a mercury content of 10 ppm or greater, to $341,000,000 to cover all sediment with a mercury content greater than or equal to 1 ppm.

Another measure that could be investigated would be to dispose of the contaminated sediments into the naturally deep basins of Onondaga Lake followed by capping, which may be more feasible than constructing confined disposal sites or capping the entire lake bottom. Obtaining the necessary permits from the State and Federal regulatory agencies would be required.

4.5.5 In-lake Treatment - Water quality in the Lake can also be changed by treating the water in general. Two rehabilitation measures considered would increase the lake's oxygen levels and decrease its phosphorus content.

4.5.5.1 Aeration of the Deep Water (Hypolimnion) - Nutrient rich water, as found in Onondaga Lake, leads to nuisance algae growth, lack of oxygen in the deeper water layers, and a general deterioration of water quality. Artificial introduction of oxygen into a water body is often used to reduce certain undesirable conditions associated with a body of water rich in dissolved nutrients. Two principal means of introducing oxygen into the various water layers of the lake can be used: de-

stratification and hypolimnetic aeration. De-stratification would involve the up-well of oxygen poor deep waters (hypolimnion) to the surface where it would be mixed with oxygen rich surface water (epilimnion) and semi-oxygen rich water (thermocline). A properly designed de-stratification system can improve water quality, but may lead to greater system problems. On the other hand, hypolimnetic aeration consists of introducing oxygen into the lake's oxygen deficient deep waters (hypolimnion), without changing the thermal stratification of the lake. This method has various advantages over de-stratification including: control on nutrient production and recycling and the production of cold, well-oxygenated water during the warm months that can be used to support a cold water fishery for trout, salmon, and related cold water fish. For example, a cold water fishery could be established if dissolved oxygen concentrations were above 6 mg/1. It would also significantly reduce the solution of metals from the sediments as well as eliminate or reduce the formation of hydrogen sulfide, methane, and ammonia. It would also help eliminate/reduce/control nutrient recycling from the sediments. For these reasons, various methods of introducing oxygen into the deep water of the lake were investigated.

Oxygenation devices fall under three main categories: mechanical agitation, air injection and oxygen injection. There are several types under each category. The most important parameter for all of these methods is the oxygen transfer efficiency. Oxygen transfer efficiency can be described as the amount of oxygen that is absorbed into the water per a specific amount of oxygen and energy input to the system. This is discussed in more detail in the Water Quality Annex.

The preferred method of water oxygenation would achieve the water quality goals described previously while not destroying the lake's stratification, not increasing the temperature of the hypolimnion that occurs naturally, not increasing the hypolimnetic volume, not increasing the dissolved nitrogen concentration, and not disturbing or mixing bottom sediments. The preferred method would also depend on the deepness of the lake, the volume of the hypolimnion and the amount of oxygen needed to be introduced into the hypolimnion.

Dissolved oxygen concentration levels were calculated for the lakes epilimnion and hypolimnion from the Onondaga County Sampling Program (April 1990). The hypolimnion is taken as the water below the 10 meter depth. The oxygen deficit present in the hypolimnion will necessitate aeration levels to be in the range from 12 to 15 pounds of oxygen per minute. This amount of oxygen addition would maintain the dissolved oxygen concentration of the hypolimnion at the level that existed at the onset of the summer stratification, assuming 100 percent efficiency for the injection system.

The above oxygen deficit rate would require the pumping of 800 cubic feet of air per minute, using a bubbler or air lift system operating at 100 percent efficiencies. These

systems efficiencies may range from 25 to 50 percent. At these efficiency levels, large amounts of nitrogen would tend to be absorbed into the water causing super saturation and aquatic organism problems. Air lift systems could either expose hypolimnetic water to warm surface air or vent large amounts of air to the atmosphere causing stratification imbalances and mixing. Consequently, air systems were ruled out as a means of oxygenating the lake due to the shallowness of the hypolimnetic layer, the possibility of nitrogen supersaturation, and the large quantities of air needed due to low absorption efficiencies.

An oxygen injection system would best meet the water quality improvement goals and be the most cost effective. In an oxygen injection system, liquid oxygen is stored on shore and is passed through a heat exchanger and turned to a gas. This pressurized gas is forced along a hose to diffusers placed at the bottom of the lake. Liquid oxygen injection is more efficient than traditional aeration systems since the traditional aeration systems deliver air, which is only 20 percent oxygen. Thus for the same volume of oxygen to be delivered to the lake, five times as much air must be pumped into the lake water than if liquid oxygen is used. Since liquid oxygen is 100 percent oxygen, diffusion of oxygen out of bubbles is faster. Figure 16 on the next page provides an illustration of a possible oxygenation system. Since oxygen will be injected into two basins of the lake, two oxygenation units are required, each delivering 7 to 7.5 pounds of oxygen to lake waters per minute. The oxygenation system will be used seven months of the year from April through October.

A preliminary cost estimate was made for the oxygen injection system. The cost estimate includes planning, engineering and design, construction management, setup costs, contingencies , as well as the cost of the liquid oxygen. Physical plant construction costs, with contingencies, are $ 1,378,000.

This measure would help produce an acceptable cold water fishery during summer stratification. However, it would not support other goals of producing acceptable swimming areas since water transparencies would not be improved nor would this measure decrease coliform bacteria concentrations.

4.5.5.2 Chemical Treatment - This measure calls for adding the chemical alum to the lake's waters to remove phosphorous from the water column. A one time application of the alum would cost at least $12,000,000. This treatment would cause a temporary decrease in the lake's total phosphorus concentrations. However, due to the influence of METROs input, phosphorus concentrations would be back to 0.11 mg/1 in about a year. This measure would temporarily increase water transparencies above the state standards for swimming. However, it would have no effect on the fecal coliform concentrations. A temporary increase in hypolimnion dissolved oxygen would take place (fishery goal), but would probably not last more than a couple of seasons. The nitrogen problem would still remain as well as problems regarding

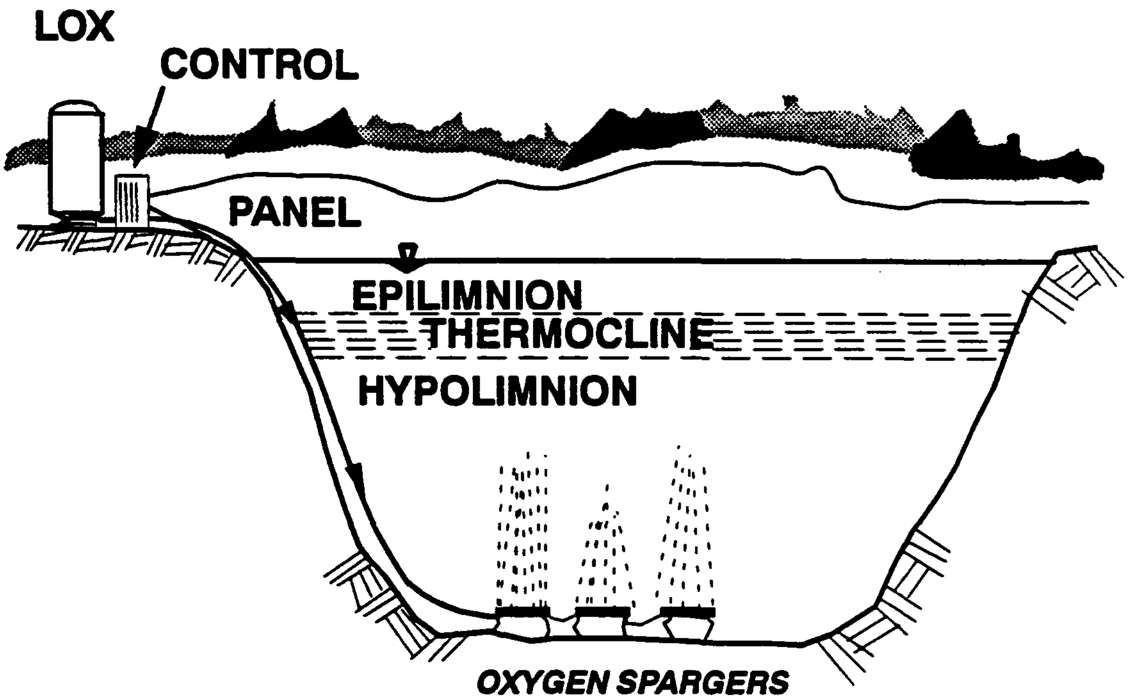



**Figure 16** - Possible Oxygenation System

acceptable concentration levels of: ammonia, nitrite and/or nitrate, mercury and chloride. This measure would not improve the lake as a drinking water source.

4.5.6 Non-point Sources - A major non-point source of sediment has been identified in the Onondaga Creek watershed in Tully Valley. The source has been isolated to an area where sediment is introduced into the surface water through the groundwater. This is known as the "Mud Boil" phenomenon. Water from a tributary of Onondaga Creek flows through these "Mud Boil" areas, picks up a sediment load, and carries it down Onondaga Creek to the Lake. Recent studies by New York State DEC indicate mud boil effluent contains 25 to 75 percent sediment. This is having a significant impact on the clarity of Onondaga Lake, and was identified by the Conference as an item which could be started immediately.

The largest mud boil field is located approximately 1,800 feet south of Otisco Road. This mud boil field has grown from 200 feet long by 80 feet wide in 1972, to 625 feet by 575 feet in 1989. A second mud boil area appeared in 1987, several hundred feet to the west of the Otisco Road mud boil. This second area continues to grow at a rapid rate, as does the main area. This source of sediment must be reduced in order to clean up the lake and improve the environment for the fisheries.

The measure which addresses the mud boil was identified as an early action item. The measure consists of diverting the tributary which runs through the mud boil field and excavation of a settling basin to trap the sediment emanating from the residual flow. The excavated diversion channel would have a 5 foot bottom width, 1 vertical and 2 horizontal side slopes, and be about 10 feet in depth and 1,200 feet long. The existing tributary, which the cut will join, must be enlarged to accommodate the additional flow. This cut will be approximately 800 feet long. The settling basin would be located just upstream of the "Mud Boil" tributary's confluence with Onondaga Creek. It will be 500 feet long by 40 feet wide and have a depth of 8 feet. This configuration will trap approximately 98 percent of the sediment which enters the basin. The accumulated sediment will have to be removed on an annual basis and spoiled at an upland site. The trapped sediment would be about 910 tons/month or 440 cubic yards/ month. A preliminary cost estimate for the proposed plan was developed. This cost includes the diversion, the settling basin, as well as planning, engineering and design, construction management and contingencies. All costs are in January 1991 price levels. Construction costs are $348,000. In addition, the cost to remove the sediment every year, is $70,000. Any cost for an upland spoil site is not included in this cost estimate.

Due to the sensitivity of issues surrounding the mud boil problem, only one possible solution was presented here. Coordination with U.S. Soil Conservation Service and US Geologic Survey staff has revealed that additional measures may be feasible, such as: construction of a retention basin to increase the hydrostatic pressure over the mud

boils, the construction of dewatering wells, or construction of an exfiltration piping network. Any of these measures may significantly curtail or draw off subsurface waters from the mud boil area.

The Onondaga Lake Management Conference has initiated, in the Fall of 1991, a demonstration project in the mud boil area based on a plan similar to the mud boil remediation plan presented in this report. The Conference has been coordinating with the U.S. Soil Conservation Service to construct a diversion channel that is scheduled for completion by Spring of 1992.

Another possible non-point source pollution is the Allied waste beds. Because these waste beds are a subject of litigation and outside the scope of this technical report, alternative measures were not formulated in this report to address them. A Wastebed Feasibility Study dated February 1990 by Blasland & Bouck Engineers provided a description of possible remediation alternatives that ranged in cost from $400,000 to $95,300,000.

4.5.7 Natural Development - The following measures are potential environmental enhancement considerations if water quality is improved in the Onondaga Lake drainage basin. At the northwest end of Onondaga Lake, within the area identified as being "cut and fill land" in the Soil Survey Report of Onondaga County (U.S. Soil Conservation Service, January 1977), there are five small low lying areas that are saturated annually. They are cut off from the lake by a narrow strip of land containing a recreational trail. This area would make an excellent site to be developed as a wetland. It is already interspersed with aquatic plants. These low lying areas should be evaluated as to the feasibility of accomplishing access connections with the lake, in order to allow for seasonal flooding of vegetation by lake water during periods of higher lake water levels, as well as to provide vegetated shallow aquatic habitat that can be either seasonally or permanently accessed by warm water fish to use for spawning and/or feeding. It may be possible that northern pike could be attracted to these vegetated low lying areas to spawn during the early part of the spring season. These areas may also provide spawning and nursery habitat for some other warm water fish, such as bass and pan fish, if adequate water levels are available in these areas during the later part of the spring season when water temperatures are higher. Further, if water levels can be maintained during the waterfowl nesting season (through the possible use of water control structures), some contribution toward the enhancement of breeding, feeding, and brooding wetland habitat for waterfowl may also be improved.

Lacustrine emergent wetlands along the south and west shorelines of Onondaga Lake could be further evaluated as to potential for fisheries and wildlife habitat enhancement.

Another enhancement would be to install wood duck nest boxes, nest baskets, and/or Canada goose nesting platforms in existing wetlands. Such nesting structures should be placed in locations that would have low potential for human disturbance.

Establishing vegetation planting in and around Onondaga Lake would be another enhancement. Plantings should be in locations where tributary streams contain trout, have water areas that are more exposed to sunlight due to paucity or absence of riparian vegetation, or where stream banks are subject to erosion and siltation by runoff. Such plantings would contribute to the development of a fishery by providing habitat for shade as well as a source of detritus to the stream and a reduction of sediment introduced into the water.

The conditions at Onondaga Lake presents the opportunity of providing a nearby wildlife area in the confines of an urban area. The development of measures to enhance the presence of fish migration, waterfowl, or migratory birds is considered advantageous. The cost to develop this natural development measure can vary from several thousand dollars for nesting boxes and vegetative plantings to several hundred thousand dollars for construction of wetland areas with control structures; depending on the magnitude of the actions taken.

**4.6 Further Measures** - These measures are part of the "Without Condition", as they may be implemented whether or not Federal agencies or the Management Conference is involved. However, these measures are discussed in this report as problems with the METRO sewage treatment plant and combined sewer overflows that impact directly on the water quality problems of Onondaga Lake. In addition, the issue of how Onondaga Lake will respond to any of these measures has yet to be determined. To answer this question, first an estimate of the reduction each measure will have in the pollutant loadings has to be done. Then this estimate is used as input to the models which are currently under development to determine how the Onondaga Lake will respond to each reduction.

The New York State Department Of Environmental Conservation (NYSDEC) has been actively involved in the cleanup of Onondaga Lake. NYSDEC developed a cleanup strategy for Onondaga Lake that includes reviewing the major problems of the lake and their contributing causes, outlining the status of applicable NYSDEC programs and activities and identifying necessary future actions to address each of the various problems. A special area of interest was water quality problems associated with municipal sewage discharges, including problems of bacteria, dissolved oxygen, transparency and ammonia toxicity. One of the major contributors of pollutant loadings to Onondaga Lake is discharges of untreated sewage.

In accordance with the Consent Order Settlement of 31 January 1989 between Onondaga County and NYSDEC, Onondaga County was required to submit to

NYSDEC a report by an independent engineering consultant which sets forth methods "that could be used to upgrade METRO and/or divert METRO discharge flows and/or divert the Combined Sewer Overflows (CSO)." The objective of the current studies and projects by the Onondaga County Department of Drainage and Sanitation, is to plan, design and construct the necessary facilities to bring all discharges into Onondaga Lake and its tributaries into State compliance.

***The current sewer system is a combined sewer system. It carries storm water as well as residential and commercial sewer discharges, and when a storm exceeds the capacity of the sewage treatment plant, the combined flow is discharged into Onondaga Lake or one of its tributaries.***

*Existing System Description*

The Combined Sewer Overflow Facilities Plan Update was completed in February 1991 for the Onondaga County Department of Sanitation. Potential remedial measures for pollutants coming from METRO and combined sewer overflows fell into three major categories: upgrade the current METRO facility to improve its treatment capabilities and to improve the removal of various chemicals (phosphorus, ammonia, nitrogen), divert METRO's combined sewer overflows to a number of regional facilities with return of treated water to the current Metro site, or develop new centralized transmission and treatment facilities for the combined sewer overflows. Each of these remedial measures is discussed below.

In addition to these remedial measures, consultants have investigated the construction of a separate waste water system. The estimated cost for such a system is $550,000,000 based on a 1979 O'Brien and Gere report. This would entail using the existing combined sewer system for rainwater. The sanitary laterals would have to be separated from the existing storm system and reconnected to the new sanitary system. This would eliminate combined sewer overflows and all sanitary flow would be treated prior to discharge to Onondaga Lake. This would be extremely disruptive, since it would require the excavation of trenches and installation of sanitary sewers in every street which has sanitary discharges. The process would not eliminate pollution but reduce it, since it is estimated that approximately 50 percent of the urban area storm water runoff contaminants would still pass untreated.

<u>4.6.1 Metropolitan Sewage Treatment Plant (METRO STP)</u> - The following is a discussion of the measures for METRO STP.

4.6.1.1 Pump Station Upgrading and/or expansion - Upgrades or expansions at the Liverpool Pump station and Ley Creek STP would result in eliminating NYSDEC violations. Raw sewage had overflowed from these two sites and their service areas. This is due primarily to excessive flow in the system, the

lack of capacity of both pump stations, and lack of capacity in the Ley Creek interceptor that allow continuous dry and wet weather discharges to be bypassed directly into the Lake. These projects were completed in 1991.

4.6.1.2 Phosphorus, Ammonia, and Nitrogen Removal - Development of treatment programs at the METRO STP to reduce phosphorus, ammonia and nitrogen emissions to the Lake. The METRO STP effluent and overflow accounts for approximately 85 percent of the phosphorus loads to Onondaga Lake. A test phosphorus removal procedure was implemented for a two month period in the summer of 1990. Phosphorus removal was by chemical precipitation using iron salts and had an efficiency rating of about 85 percent. The METRO STP is not designed for ammonia removal. However, with some plant upgrades, an ammonia concentration of 2 mg/1 should be achieved for both seasonal or year round nitrification. Upgrading the METRO STP for year-round ammonia removal would require larger facilities and significantly greater cost than only upgrading for seasonal removal. Upgrading of the METRO STP for nitrogen removal could achieve a total nitrogen concentration of 10 mg/1 or less in the effluent. METRO STP effluent represents up to 85-90 percent of the external nitrogen loading to the lake.

4.6.1.3 Effluent Discharge Alternative - METRO STP could construct a new bypass effluent outfall discharged into the Seneca River, instead of the Lake. Discharge of METRO STP effluent into the Seneca River would remove all of the sewage related pollutants currently entering Onondaga Lake. However, a study of the impact on water quality in the Seneca River would have to be performed. This work will require input from the updated Three Rivers Model, currently being prepared by Upstate Freshwater Institute.

4.6.2 Combined Sewer Overflow (CSO) Treatment and or Diversion (Reference Water Quality Annex, Section 5.2) - The importance of combined sewer overflow (CSO) as a major source of contaminants to Onondaga Lake has long been recognized. The addition of new residential, commercial and industrial developments is making the problem worse. There are 45 CSO's which discharge into Onondaga Creek, 19 CSO's that discharge into Harbor Brook and 2 CSO's that discharge into Ley Creek. These CSO's are a source of fecal coliform bacteria, BOD, nitrogen and phosphorus. Because a separate system would cost $ 550,000,000, less costly alternatives were considered. They were:

4.6.2.1 Best Management Practice (BPM) - In the early 1980's, the concept of a Best Management Practice (BMP) Policy was developed as part of a CSO Master Plan for Onondaga County. This policy had two phases:

(1) Phase I optimized the existing systems capacity. Based on this work a number of sewer system improvements were implemented within the city of

Syracuse. A post BMP assessment in 1987 demonstrated that measurable improvements in system performance and water quality would result from the various collection system improvements.

(2) Phase II developed structural solutions. The CSO Master Plan for Onondaga County was to include installation of 21,000 linear feet of CSO transmission pipelines, construction of six satellite CSO treatment facilities and modification of two existing demonstration CSO treatment facilities. At the current time, Phase II has not been implemented nor has final design of any of the Phase II elements been initiated. However, an updated CSO facilities Plan was recently completed and provides several CSO abatement alternatives.

4.6.2.2 Regional Collection And Treatment Facilities (reference Water Quality Annex, Section 5.2.2) - The regional concept requires the construction of CSO interceptor pipelines that lead to high rate treatment facilities. Treatment would include the removal of most solids followed by high rate disinfection. Concentrated solids in the underflow would be returned to the interceptor sewers for conveyance to the METRO STP.

The Combined Sewer Overflow Facilities Plan Update, completed in February 1991 for the Onondaga County Department of Sanitation, addressed the regional approach to treating CSOs. The report recommended ten regional facilities. Eight of the regional facilities would be new facilities and two would require upgrading of existing facilities. There were six regional facilities serving the Onondaga Creek area, two serving Harbor Brook and two serving the Ley Creek area. This regional CSO treatment scheme would increase suspended solids and associated organic and nutrient loadings received at the METRO STP during wet weather. This would impact on the operation and performance of grit removal, primary settling, and sludge treatment facilities. Expansion of METROS existing sludge thickening facilities would be required to reduce the impact of additional CSO solids. The extent of the expansion will be dependent on other factors, including the method of phosphorus removal and the feasibility of pumping tertiary chemical sludge direct to dewatering. Fecal coliform loadings conveyed to METRO from regional CSO treatment facilities will increase the chlorine demand at the bypass chlorination facilities. Currently the bypass chlorination facilities are operated manually. Discharge options with the regional treatment alternative includes both Onondaga Lake and the Seneca River.

4.6.2.3 Centralized CSO Transmission and Treatment Facilities (Reference Water Quality Annex, Section 5.2.3) - Centralized transmission and treatment of CSO discharges along Onondaga Creek and Harbor Brook to a central point in the vicinity of the METRO STP was investigated. The treatment of CSO discharges associated with the centralized concept looked at three alternatives. Discharge options with all centralized treatment alternatives included both Onondaga Lake and the Seneca River.

(1) High Rate Treatment Facility - The high rate treatment facility was sized to handle the CSO's from Onondaga Creek and Harbor Brook. Ley Creek CSO discharges would not be routed to the high rate treatment facility due to the low ratio of CSO volume to total creek volume. Both of the CSO's in the Ley Creek basin are remote from each other and the METRO STP. Any centralized treatment scheme would require construction of long pipelines. Separate and combined transmission pipeline schemes were developed for Onondaga Creek's and Harbor Brook's CSOs. The impacts on METRO STP during wet weather conditions, would be the same as those discussed for the regional CSO treatment alternative. Expansion of certain METRO STP components will be needed to accommodate the additional loadings. Again the extent of expansion will be dependent on other factors, including the need for additional treatment for improved phosphorus removal, ammonia removal and nitrogen removal. Therefore, the impact on METRO facilities cannot be fully evaluated until the effluent requirements are more clearly defined.

(2) "In-Water" Treatment - The construction of an "In Water Facility" was deemed appropriate for the temporary storage of CSO discharges from the Harbor Brook Basin. Handling the entire discharge would not require the construction of a centralized pipeline, but would require a Flow Balance Method (FBM) facility capable of handling brook water as well as CSO discharges. Actual storage takes place in an existing waterway, thus saving the great expense of constructing comparable facilities on the shore. It can then be pumped to a treatment facility for final treatment. Alternatively, if these treatments (settling and disinfection) could occur at the in-water facility, it would eliminate the need to pump the captured CSO to a treatment plant. NYSDEC has rejected this plan, as being unacceptable to the public.

(3) In Line Storage Tunnels - Finally, CSO's from either Onondaga Creek or Harbor Brook could be temporarily stored in tunnels. These CSO's would then be pumped out, over a two to three day period after the storm, to either METRO STP or a dedicated CSO treatment facility. The associated volumes of storage are the same as the values noted for the FBM facility.

4.6.2.4 Detention Reservoirs - Detention reservoirs were investigated during the earlier CSO studies for the METRO service area and were eliminated due to space restrictions and prohibitive costs. The available storage in trunks sewers, interceptor pipelines, and swirl concentrators was considered under the present alternatives. In addition, limited detention basin analysis was included with an FBM facility for Harbor Brook.

4.6.2.5 Summary - Advantages of CSO abatement include:

(1) the elimination of CSO discharges from the creeks into Onondaga Lake for all storm events less than the design event, and

(2) under the scheme of discharging treated CSO's into the Seneca River instead of Onondaga Lake, the elimination of all CSO related pollutant

discharges into Onondaga Lake.

The elimination of CSO pollutants into local streams, particularly on Onondaga Creek, will help achieve the goal of a fishing resource on Onondaga Lake. This centralized concept will also help achieve other "multiple use" goals such as the establishment of recreational facilities along the Onondaga Creek and Harbor Brook corridors. Disadvantages include the cost of construction and possible need to reconstruct bridges and stream carrying capacity due to the increased outflows from the centralized facilities.

### 4.7 Summary of Measures

The cost estimates for each measure except the METRO sewage treatment plant and combined sewer overflow measures are summarized in Table X. Detailed cost estimates, providing quantities, unit prices, and subtotals, are provided in Annex A - Water Quality Technical Annex. Onondaga County has not released their estimates for the METRO sewage treatment plant and combined sewer overflow improvement measures.

## Table X - Cost Estimate Summary of Measures, Onondaga Lake

| Cost Estimate Summary of Measures<br>Measure Definition | Total First Cost<br>$ |
|---|---|
| 1. Dredging of Onondaga Lake | |
| a. 6,500,000 Cubic Yards | 61,700,000 |
| b. 3,000,000 Cubic Yards | 28,500,000 |
| c. 2,000,000 Cubic Yards | 19,100,000 |
| 1.1 Confined Disposal Facilities (Integral with dredging) | |
| a. Design 1 (Confine 6.5 million CY in 22' of water) | 63,500,000 |
| b. Design 2 (Confine 6.5 million CY in 6' of water) | 50,700,000 |
| c. Design 3 (Confine 3 million CY) | 20,700,000 |
| d. Design 4 (Confine 2 million CY) | 17,500,000 |
| 1.2 Solidification of Contaminated Sediments ($80/CY) (Integral with dredging) | |
| a. 6,500,000 Cubic Yards | 520,000,000 |
| b. 3,000,000 Cubic Yards | 240,000,000 |
| c. 2,000,000 Cubic Yards | 160,000,000 |
| 2. Capping of Contaminated Sediments (0.5 feet sand) | |
| a. < 1 ppm mercury | 198,000,000 |
| b. < 5 ppm mercury | 162,000,000 |
| c. < 10 ppm mercury | 143,000,000 |
| 3. In-lake Treatment | |
| a. Aeration of the Hypolimnion | 1,378,000 |
| b. Chemical Treatment | 12,000,000 |
| 4. Non-point Sources | |
| a. Mud Boils on Onondaga Creek | 348,000 |
| b. Waste Beds | 400,000 to 95,300,000 |
| 5. Natural Development | 10,000 to 400,000 |
| 6. Metro Sewage Treatment Plant | |
| a. Phosphorus, Ammonia, & Nitrogen Removal | N/A |
| b. Effluent Discharge Alternative | N/A |
| 7. CSO Treatment or Diversion | |
| a. Regional CSO Treatment Facilities | |
| ○ Separation of Combined Sewer Systems | N/A |
| ○ Storage options | N/A |
| b. Centralized Treatment & Storage | |
| ○ High Rate Treatment Facilities | N/A |
| ○ In-water Containment Structures | N/A |
| ○ In-line Tunnel Storage | N/A |

# 5 - EVALUATION OF ALTERNATIVES

## 5.1 General

This section groups the measures discussed in Section 4 to address the basic planning objectives. This section also provides the rationale for combining measures into preliminary alternatives. These alternatives would require more final planning and design prior to proceeding to construction. A summary of the measures is presented in the shaded area to the right.

The evaluation of these measures was based primarily on a literature review, and was intended to assess the current work to determine if additional work is required before the water quality problems of Onondaga Lake can be solved. The evaluation is aimed at addressing a comprehensive solution and attempts to bring together all the work currently underway in one technical document.

***<u>Summary of Measures</u>***

1. *Dredging of Onondaga Lake & Disposal*
2. *Capping of Contaminated Sediments*
3. *In-lake Treatment*
   a. *Aeration*
   b. *Chemical*
4. *Non-Point Sources*
   a. *Mud Boils on Onondaga Creek*
   b. *Waste Beds*
5. *Natural Development - Environmental Enhancement, Wetland & Wildlife*
6. *Metro Sewage Treatment Plant*
   a. *Phosphorus, Nitrogen, Ammonia removal*
   b. *Discharge to the Seneca River*
7. *Combined Sewer Overflow (CSO) Treatment and or Diversion*
   a. *Regional Collection & Treatment*
   b. *Centralized Transmission & Treatment*

## 5.2 Economic Methodologies

The economic evaluation was performed during the preparation of this technical report was limited to an investigation of methodologies. The emphasis has been on defining the problem and assessing the work to date with the goal of identifying potential solutions. The economic evaluation in this phase has concentrated on identifying the best methodologies and procedures to measure the benefits associated with the clean up of Onondaga Lake. While it is possible that components of an individual plan could pass the National Economic Criteria (NED) criteria, it is unlikely that an entire plan could be formulated that, based solely on NED, would solve the problem. This approach is consistent with the published Principles & Guidelines. Specifically, the NED analysis would be integrated into a multi-criteria model. These model results would then be used to select the "best" combination of measures.

## 5.3 Evaluation

For this report the measures which are shown in the shaded area in Section 5.1 on page 66, were first evaluated based on their impact of reducing specific pollutants. The water quality annex provides a detailed analysis of the results of this analysis. Each measure was evaluated against the following parameters: bacteria, phosphorus, nitrogen, dissolved oxygen, water transparency, ammonia, heavy metals, organic compounds, ionics, and mercury.

The list, as shown in the matrix that follows, was narrowed by considering only those parameters which were considered most important to the achievement of the three water quality goals: drinking, fishing, and swimming. In addition, the measures were evaluated relative to their impact on the Seneca River and the productivity of the lake. Based on that comparison, the parameters were reduced to: bacteria, phosphorus, nitrogen, dissolved oxygen, transparency, mercury, and chlorides (ionic). The results of this comparison are summarized in Table XI. Table XI also shows the contribution each measure has toward the individual goals (drinking, fishing, and swimming). It

**Table XI** - Measures Affect on Critical Onondaga Lake Water Quality Parameters & Water Quality Goals

| | Measures Identification (Reference Shaded Area Previous Page) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Critical Parameters** (2) | **1** | **2** | **3a** | **3b** | **4a** | **4b** | **5** | **6a** | **6b[3]** | **7a** | **7b** |
| **Bacteria** | . | . | . | . | . | . | . | . | . | + | + |
| **Phosphorus** | . | . | . | + | . | . | . | + | + | . | . |
| **Nitrogen** | . | . | . | . | . | . | . | + | + | . | . |
| **DO** | . | . | + | . | . | . | . | + | + | . | . |
| **Transparency** | . | . | . | + | + | . | . | + | + | + | + |
| **Mercury** | + | + | . | . | . | . | . | . | . | . | . |
| **Chloride** | . | . | . | . | . | + | . | . | . | . | . |
| **Goals Addressed[1]** | F | F | F | F | F | F | F | F | F | | |
| | | | S | S | S | | | S | S | S | S |
| | | | | | | D | | D | D | | |

**Notes:** 1. F=Fishing, S=Swimming, and D=Drinking; Although the measure may address one of these, it does not necessarily solve the problem.
2. (+) Plus signs indicate the measures could significantly improve Onondaga Lake water quality for that parameter.
3. For alternative 6b the impact on the Seneca River would need to be evaluated.

should be noted that just because a measure is listed as contributing to a goal, that does not mean that the goal has been met.

### 5.4 Rationale for the Grouping of Measures into Alternatives

This section illustrates how the various measures could be combined to address specific objectives. As explained earlier in this report, no economic evaluation was conducted, rather a qualitative analysis was done. In addition, because not all the models are complete, it was not possible to evaluate the interrelationships among the various measures. Therefore this section is restricted to illustrating which groups of measures are good candidates for further investigation to address a specific objective.

Very preliminary cost estimates are provided on some measures, to give the reader a feel for the magnitude of the measure's cost. Dredging, disposal and capping are relatively costly measures that address only the mercury problem. These measures should be given further consideration when additional information on sources and cycling is available. In-lake chemical treatment is also a costly measure. Its effectiveness is only temporary and the reduction in phosphorus concentrations in the lake may not result in a noticeable reduction in algae growth. The METRO diversion around Onondaga Lake will have a positive impact on the lake's water quality; however, its impact on the Seneca River is currently unknown.

5.4.1 Alternatives to Address Onondaga Lake Goals - As has been discussed earlier in this report in Section 3 under Planning Objectives, three primary goals were established for Onondaga Lake. They are to: 1) Produce a lake acceptable for contact recreation (swimming); 2) Produce a lake acceptable for a cold water fishery (fishing); and 3) Produce an acceptable drinking water supply with minimal treatment (drinking water). These goals have been addressed by first formulating alternatives that address each individually and then formulating a multi-goal alternative. The list of measures on page 66, paragraph 5.1 were referenced to develop a table of alternatives (Reference - Table XII). It must be noted that the potential exists for antagonistic impacts of combined remediation. For example, options that improve transparency coupled with those that increase dissolved oxygen and enhance nitrification might cause more algal production.

5.4.1.1 Single Goal Alternatives - The various individual measures have been combined to produce the minimum first steps to achieve the restoration goals.

(1) Alternative 1 - Swimming: The first steps to achieve bathing beaches that meet New York State standards are: control of CSO discharges (Measure 7), additional removal of phosphorus by METRO (Measure 6a), control of mud boils (Measure 4a), and in-lake oxygenation (Measure 3a).

Table XII - Alternatives, Onondaga Lake

| Grouping of Measures into Alternatives - Onondaga Lake | |
|---|---|
| Alternatives | Measures |
| **Alternative 1** - Swimming | Measure 3a - In-lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 6a - Removal of Phosphorus at METRO<br>Measure 7 - Control of CSO discharges |
| **Alternative 2** - Fishing | Measure 3a - In-lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 4b - Control Leaching from Waste beds<br>Measure 6a - Removal of Phosphorus & Nitrogen at METRO |
| **Alternative 3** - Drinking | Measure 3 - In-Lake Oxygenation<br>Measure 4b - Removal of Chlorides<br>Measure 6a - Removal of Phosphorus, Nitrogen, & Ammonia at METRO |
| **Alternative 4** - Multi-goal (Swimming, Fishing, Drinking) | Measure 3 - In-Lake Oxygenation<br>Measure 4a - Control of Mud Boils<br>Measure 4b - Control Leaching from Waste Beds<br>Measure 6a - Removal of Phosphorus, Nitrogen, & Ammonia at METRO<br>Measure 7 - Control of CSO's |
| **Alternative 5** - Natural Development | Measure 5 - Environmental Enhancement for Wetlands and Wildlife |

**Note: Measure 6b may prove more effective than Measure 6a in these alternatives. The most effective measure to reduce pollutant loads to Onondaga Lake is re-routing of METRO discharge. It is likely this would require additional pollution abatement measures to avoid detrimental effects on the Seneca River. Current modeling efforts are addressing this issue.**

The regional collection and treatment of CSOs will reduce the average number of days per year that the coliform standards are exceeded from about 40 to 3. The introduction of oxygen into the deep water will reduce phosphorus release from the bottom sediments. This would reduce the total phosphorus load by about 12 percent.

(2) Alternative 2 - Fishing: The first steps toward developing a cold water fishery are: additional phosphorus removal by METRO (Measure 6a), advanced treatment for nitrogen removal (Measure 6b), in-lake oxygenation (Measure 3a), control of mud boils (Measure 4a), and control of leaching from the waste beds (Measure 4b) (chlorides).

The lake will benefit from additional removal of phosphorus; however, even with reductions as low as 0.1 mg/l of phosphorus, the lake will still remain eutrophic. Oxygenation could reduce the lake's production of phosphorus, and probably eliminate the ammonia problems in the deep water. However, its unknown what the impact will be on polluted sediments (in particular, mercury), or if it will be adequate to offset the input of ammonia from external sources. The Onondaga Lake Management Conference is funding studies in 1992 to determine if the amount of phosphorus in the lake will be reduced or will increase by artificially adding oxygen to the lake. The results of these studies will assist in determining if in-lake oxygenation will be effective. The advanced treatment of nitrogen could reduce the algal production, eliminate the ammonia and nitrite problems, increase the transparency, and increase the amount of dissolved oxygen in the deep water basins. Eliminating the leaching of chlorides from the waste beds would bring the lake's chloride concentrations within New York State DEC standards for a cold water fishery. The control of the mud boils would eliminate the most significant contributor of fine grained sediment. This would significantly increase transparencies in both the southern end of the lake and Onondaga Creek. The creation of wetlands may also be required to provide sufficient spawning habitat to sustain the fishery.

(3) Alternative 3 - Drinking Water: The first steps to achieve drinking water standards (with some treatment) for Onondaga Lake are: additional removal of phosphorus by METRO (Measure 6a), removal of chlorides (Measure 4b), oxygenation (Measure 3), and elimination of ammonia problems (Measures 4b & 6a). Denitrification of the METRO effluent may also be necessary to reduce nitrate concentrations in the lake (Measure 6a).

5.4.1.2 Alternative 4 - Multiple Goal Alternative for all three goals (drinking, fishing & swimming): The first steps to achieve this alternative are: control of CSOs (Measure 7), additional phosphorus removal (Measure 6a), control of the mud boils (Measure 4a), increasing the lake's oxygen (Measure 3), control of leaching from the waste beds (Measure 4b), and ammonia nitrification with possible denitrification at METRO (Measure 6a).

This alternative has the same combination of measures as the swimming and cold water fishery alternative. The interrelationship of the measures cannot be determined until all the modeling is complete. Consequently, it is not possible to determine parameter targets for each measure. These are the starting measures. The "best"

combination of measures will require additional detailed study.

5.4.1.3 Alternative 5 - Natural Development: Environmental enhancement measures were also formulated in a measure for natural development (measure 5) and would mostly contribute to the fishing goal. However, a cursory evaluation indicated that improving the wildlife habitat in the vicinity of the lake would not only benefit the fishing objective, but also improve the value of the lake for other recreational activities. Defining the value of a healthy thriving lake in the middle of an urban area is in many respects, highly subjective, but by any measurement it must be a significant contributor to the emotional and social well-being of the local inhabitants.

## 5.5 Rationale for Elimination of Alternatives from Further Consideration

Currently there are insufficient information and data to eliminate any measures or alternatives from further study. Additional modeling must be done before any attempt to formulate a mix of measures which would efficiently clean up Onondaga Lake. The models will predict how the lake will respond to changes in pollutant and nutrient loadings. In addition to the models, analysis is needed to quantify the impact the various measures will have on the pollutant and nutrient loads to the lake. These loadings are the basic data the models use to predict how the lake will respond. Without both the models and the loadings, it is not possible to analyze the impacts of the various tradeoffs among the measures.

## 5.6 Federal Interest

Traditionally water quality remediation is not a Corps mission. In addition, the determination of a Federal interest in this type of work traditionally has fallen on the U.S. Environmental Protection Agency (EPA), and EPA's decision to proceed can involve factors other than a comparison of costs and benefits.

# 6 - CONCLUSIONS

Based on the evaluations performed during preparation of this technical report and the review of other technical studies (listed in the Technical Annex, Bibliography), it is concluded that:

1. The most effective measure to reduce pollutant loads to Onondaga Lake is re-routing of METRO discharge. Additional pollution abatement measures would be neccesary to avoid detrimental effects on the Seneca River. Current modeling efforts are addressing this issue.

2. The METRO total phosphorus discharge is the major source of nutrients to the lake. Reduction/elimination of this loading is a necessary element, if the lake's condition is to be shifted out of the eutrophic state. Although this action alone may not be sufficient to do so, improvements would be noticeable.

3. Ammonia controls including nitrification and a reduction in ammonia due to oxygenation will benefit the fish habitat as well as the drinking water goal.

4. CSO's must be controlled to achieve the swimming goal due to their discharge of coliform bacteria.

5. The least cost bacteria reduction measure is regional collection and treatment.

6. CSO's are a small source of phosphorus loads to the lake (compared to METRO phosphorus loads) but their control may be needed as a complement to actions at METRO. The selected CSO pollution reduction measures reviewed in this report have minor effects on phosphorus loads to the lake.

7. Dredging and capping measures which address mercury in the sediment, are likely to be very costly. The potential improvement and associated benefits are uncertain at the present time. Studies to more thoroughly evaluate measures to control mercury will begin in 1992 through a consent decree between the State of New York and Allied-Signal.

8. Remedial control of Allied-Signal waste beds is necessary, if in-lake chloride concentrations are to be brought within state water quality goals.

9. Mud boil sediment load must be reduced significantly to enable fish spawning in Onondaga Creek and increase transparency in the lake.

10. In-lake oxygenation is a measure that may contribute to noticeable improvements to the lake if carried out in concert with other, more basic, pollution controls. These potential improvements may include reduced nutrient and metal leaching from the sediments, a reduction of methane gases, a reduction in ammonia from the hypolimnion, and enough dissolved oxygen to maintain a cold water fish population in the lake. Whether these benefits would actually occur in the specific chemical environment of Onondaga Lake needs further evaluation.

11. In-lake chemical treatment for phosphorus removal is very costly and its benefits are temporary unless the external sources are removed.

12. There is not enough information on the mercury to determine the sources or the mechanism that causes it to cycle out of the sediments.

13. There is little information on organic compounds in the lake regarding how they interact between the sediments, water and aquatic life. More studies are needed in this area to better define the organic relations with this environment.

14. If actions are taken to improve water quality and develop a cold water fishery without additional actions to deal with in-place contaminants, fish could still be inedible.

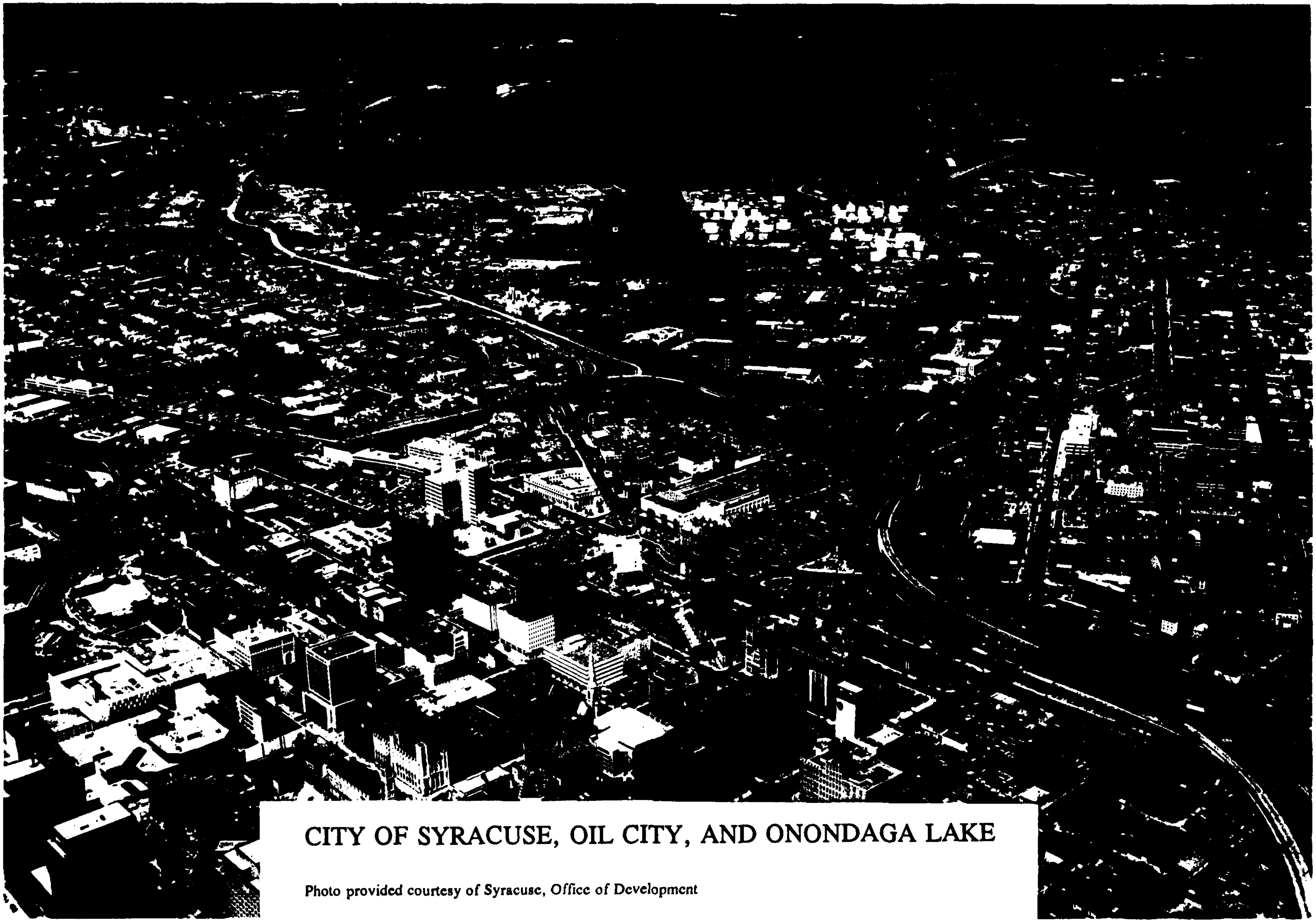
15. The current modeling efforts by the Upstate Freshwater Institute need to be completed before an efficient solution can be formulated. These efforts are needed to predict how the lake will respond to changes in nutrient and pollutant loadings. There is a need to quantify the load reductions that each measure will have on a specific pollutant or nutrient. The lake models use this input to determine how the lake will respond to proposed loading changes.

16. A traditional plan formulation process based on the single objective of NED will not identify the best plan of improvement that meets the multiple objectives of swimming, fishing and drinking for the waters of Onondaga Lake. What is needed is a multi-objective plan formulation process with an adequate decision matrix to allow for the comparison of plans based on criteria such as: cost, acceptability, effectiveness, completeness, economic efficiency, and environmental desirability. Integral with this process is the necessary public involvement to address the issues of public necessity and acceptability.

# 7 - COMMANDERS STATEMENT

The Buffalo District has reviewed numerous measures to improve the water quality of Onondaga Lake, but because the work is outside the Corps traditional missions, the Corps will not proceed with further study as authorized by a Resolution of the Committee on the Environment and Public Works of the United States Senate dated June 1989. This constitutes the final report under this authority. This technical report is provided to the Onondaga Lake Management Conference to assist the Conference in the preparation of a Management Plan for the improvement of water quality in Onondaga Lake.

John W. Morris
Colonel, US Army
Commanding



CITY OF SYRACUSE, OIL CITY, AND ONONDAGA LAKE

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